REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
MAY 1995

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
A Comparison of One-Way Video And Two-Way Video Educational Videoteleconferencing

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AFIT Students Attending:
Arizona State University

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/CI/CIA
95-020

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
DEPARTNEMT OF THE AIR FORCE
AFIT/CI
2950 P STREET, BDLG 125
WRIGHT-PATTERSON AFB OH 45433-7765

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release IAW AFR 190-1
Distribution Unlimited
BRIAN D. GAUTHIER, MSgt, USAF
Chief Administration

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

14. SUBJECT TERMS

15. NUMBER OF PAGES
93

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

A COMPARISON OF ONE-WAY VIDEO AND TWO-WAY VIDEO EDUCATIONAL VIDEOTELECONFERENCING

by
Craig L. Hendrix

An Applied Project Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Mass Communication

ARIZONA STATE UNIVERSITY
WALTER CRONKITE SCHOOL OF JOURNALISM AND
TELECOMMUNICATION

MAY 1995

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Abstract

Hendrix, C. L. (1995). A Comparison of one-way video and two-way video educational videoteleconferencing. Unpublished applied project, Arizona State University, Tempe.

The Problem

The literature reviewed in this study supported the effectiveness of educational videoteleconferencing; however, relatively little research was found comparing the two most interactive types of educational videoteleconferencing systems. An experimental research project was conducted, attempting to determine which educational videoteleconferencing system is more effective. Specifically, this project was designed to answer the following question:

Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing (EVC)?

Research Sub-questions. The following research sub-questions were developed to examine and evaluate student cognition, student/instructor interaction, and attitudes about the technology in EVC:

1. *Are there any differences in student cognition between one-way video and two-way video EVC?*

2. *Are there any differences in student/instructor interactivity between one-way video and two-way video EVC?*

3. *What is the relationship between student/instructor interactivity and cognition in one-way video and two-way video EVC?*

4. *What is the relationship between gender and cognition in one-way video and two-way video EVC?*

5. *What is the relationship between EVC experience and cognition in one-way video and two-way video EVC?*

6. *What is the relationship between attitudes about EVC technology and cognition in one-way video and two-way video EVC?*

One directional hypothesis, related to Research Sub-question 1, was developed for this study:

H_1) There is no difference in college student cognition when comparing two-way video with two-way audio EVC and one-way video with two-way audio EVC.

Method

Fourteen subjects were divided into two experimental groups to receive separate but virtually identical live instructional presentations in one of two conditions: Group A had instruction delivered by two-way video (with two-way audio) EVC and Group B had instruction delivered by one-way video (with two-way audio) EVC. During the lectures, both groups were monitored to measure the amount and type of interactions they had with the instructor. Immediately following each instructional phase, students were administered a questionnaire that included fill-in-the-blank, multiple choice, and true/false items to measure cognition of the lecture. The instrument also surveyed perceptions and attitudes about the technology used to deliver the instruction using semantic differential and Likert scales, a forced choice item, and open-ended items. Students rated the importance of student/teacher interactivity and compared EVC with traditional classroom instruction. The researcher also conducted a post-experiment interview with the instructor to determine which delivery medium he preferred and why.

Results

The data supported H_1. 1) There was no significant difference in college student cognition between two-way video and one-way video EVC groups (t=.133). The mean cognitive score for Group A was 72.5% correct while the mean cognitive score for Group B was 73.3% correct. 2) There were no differences in student/instructor interaction. All communication during the experiment was one-way. Subjects did not interact with the instructor other than to listen to the lecture. 3) Due to the absence of student/instructor interaction in this experiment, no relationships could be determined between the amount and type of interactions and student cognition. 4) There was no relationship between gender and cognition (t=0.50).

5) There was a significant relationship between EVC experience and cognition in one-way video and two-way video EVC. The 4 subjects with prior EVC experience scored significantly higher than the 10 subjects with none ($t=2.87$, $p<.02$). 6) There was no relationship between attitudes and cognition in one-way video and two-way video EVC. Both groups were more positive toward traditional classroom education than EVC. Group B was more positive about videoteleconferencing than Group A ($t=1.77$, $p<.10$) but not significantly, while Group A was significantly more positive about traditional classroom education than they were about EVC ($t=2.63$, $p<.02$).

Conclusions

Results imply that, since students performed similarly in both settings, training and educational institutions can reduce expense by utilizing the less expensive one-way video with two-way videoteleconferencing instead of two-way video with two-way audio videoteleconferencing. However, two-way video EVC offers the added benefit of visual feedback for the instructor. Although neither group of subjects orally responded to the instructor, the instructor could still see whether students were attentive and monitor their reactions during the two-way video. The finding that subjects with prior videoteleconferencing experience performed significantly better than their inexperienced counterparts ($t=2.87$, $p<.02$) could be attributed to the content of the lecture, i.e., the experienced subjects may have already been familiar with ITFS and MMDS technology.

The heuristic nature of this study makes it an ideal model for conducting further research into the effectiveness of interactive EVC systems. Longitudinal research, using this study as a model, could reveal possible differences in effectiveness as measured by cognition, interaction, and student/instructor satisfaction. A longitudinal study could circumvent several limiting factors which inhibited interaction in this study: artificiality, the short duration of the instruction, and the impact of the medium on an inexperienced EVC instructor's teaching style.

Dedication

This research is dedicated to Colonel Bill Cultice and Lieutenant Colonel "Rock" Houser. I had the great fortune of working for both of these outstanding leaders who've made an indelible impression on me. These men saw my potential and took steps to make sure I met that potential. Without Colonel Cultice's staunch support, I would never have had the opportunity to attend Arizona State University or command an Air Force detachment. "Rock" is my number one advisor. He kick-started my career on the right track 10 years ago and he's helped me stay on track with sound advice, a killer backhand, and faithful friendship ever since. Thank you both.

Acknowledgements

I'd like to thank my wife for her patience and ability to disappear from sight whenever I hit the proverbial wall while working on this project. She believed in me when I didn't, and if she had any doubts about my ability to see this through, she never once displayed them. Thank you for believing in me. I'd also like to acknowledge Elizabeth Craft, Director of Distance Learning Technology at Arizona State University, for providing the studio/classrooms to conduct this research. She saved me more than a few dollars. I'm also indebted to Tom Crosby, the instructor for the experiment, without whose help this project would never have happened. There was another person who probably endured as much as I did--Dr. Mary-Lou Galician, who had the misfortune of being my advisor on this colossal undertaking. A virtual dynamo, she spent countless hours helping me plan, conduct, organize, and write this beast. Her ability to see the overall direction of the project and, most importantly, her patience with me were remarkable. Words can't express my gratitude, but a heartfelt thank you will have to do.

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Chapter 1

The Problem

Background

Videoteleconferencing technology has yielded a variety of applications for business, education, and the military. For educators, videoteleconferencing has become synonymous with distance education--a learning arrangement that enables educators to reach geographically inaccessible students and working adults (Barney, 1990; Clark, 1989; Moore, 1989). Rural public schools and community colleges have broadened curriculums without having to hire additional instructors while major universities have gained new adult students who were previously unable to attend because of cost, time, or incapacity (Barker, 1987; Benson & Hirschen, 1988; Pirkl, 1990).

Instruction typically originates at a distant site from the learner(s) and usually involves two-way communication by means of interactive audio and/or video (Benson & Hirschen, 1988; Schamber, 1988). Electronic media or combinations of media are used to bridge the distance gap. Some of the major types of delivery media include: cable television, satellites, fiber optics, phone lines, and point-to-point microwave (Barker, Frisbie, & Patrick, 1989).

Over the years, educators have stressed the importance of instructor/learner interactivity. This interactivity has been described as two-way contact between participants and it can vary from written comments on student work to face-to-face discussions. The importance of educational interaction has been shown in a number of ways. First, interaction in the form of dialogue is a common means of educational communication. Second, some researchers have found that student performance increases with greater interactivity. Third, students work harder and score higher if they anticipate interaction (Ritchie & Newby, 1989). Studies indicate distance learners perform as well as or better than their traditionally taught counterparts (Moore & Thompson, with Clark, Goff, & Quigley, 1990).

Although many instructors have emphasized the importance of classroom interactivity, some studies have shown student needs for interaction are dependent on individual maturity and motivation (Barnard, 1992). Sounder (1993) attributed superior student performance by the distance learners in his videoteleconferencing experiment to their older ages and greater work experience. His findings, as in other studies (Bajtelsmit, 1990; Moore & Thompson, 1990; U.S. Congress, 1989), indicated that successful distance learners demonstrate a high degree of commitment and maturity. In a survey of California State University students taking videoteleconferencing courses via one-way video (with two-way audio), adult students indicated live interaction was not as important to them as high school students using the same system did. Less experienced students invariably expressed a greater need for interactivity (Barnard, 1992).

A U.S. Army study (Lehman & Kinney, 1992) found that student soldiers participating in a one-way video (with two-way audio) learning environment significantly outperformed their counterparts who received the same training via a two-way video (with two-way audio) system. Posttest results indicated that the significant differences between student scores in different delivery systems were due to differences in training methods and not differences in the way the distance learning sites were configured. The 13-month study did not observe or address the potential impact of student/instructor interactivity in either delivery system.

Of the two most interactive, full-motion videoteleconferencing systems available, one-way video with two-way audio EVC is inherently less expensive to procure and operate when compared with two-way video with two-way audio EVC. Less equipment is required and bandwidth requirements are smaller equating to reduced operating costs (Carter, 1993). In an attempt to determine which distance learning system cost-effectively produces greater cognition, student/instructor interactivity, and satisfaction; this researcher directly compared the two most interactive, full-motion videoteleconferencing systems.

Statement of the Problem

Specifically, this project was designed to answer the following question: *Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing (EVC)?*

Research sub-questions. The following research sub-questions were developed to examine and evaluate student cognition, student/instructor interaction, and attitudes about the technology in EVC:

1. Are there any differences in student cognition between one-way video and two-way video EVC?

2. Are there any differences in student/instructor interactivity between one-way video and two-way video EVC?

3. What is the relationship between student/instructor interactivity and cognition in one-way video and two-way video EVC?

4. What is the relationship between gender and cognition in one-way video and two-way video EVC?

5. What is the relationship between EVC experience and cognition in one-way video and two-way video EVC?

6. What is the relationship between attitudes about EVC technology and cognition in one-way video and two-way video EVC?

Hypothesis. Based on literature, this study hypothesized that students in both EVC systems would perform similarly. College-level student cognition has not been shown to differ significantly with the increased ability to interact with the instructor in a distance learning environment (Ritchie & Newby, 1989; Stone, 1988). Ritchie and Newby (1989) found that undergraduate students first experiencing interactive television instruction felt less involved

in the class and did not ask questions of the instructor even when two-way audio was available. One directional hypothesis, related to Research Sub-question 1, was developed for this study:

H_1) There is no difference in college student cognition when comparing two-way video with two-way audio EVC and one-way video with two-way audio EVC.

Conceptual Definitions

Attitudes: Dispositions, feelings, or preferences toward a person or thing (Hauck, Su, & Stein, 1975).

Audio: (See "Video") The audio elements of television; sounds that are transmitted and received (Hauck et al., 1975).

Cognition: The act or process of knowing through learning (Hauck et al., 1975).

College students: Undergraduate and graduate students formally engaged in learning.

Comparing: Examining two or more things for the purpose of noting differences and similarities (Hauck et al., 1975).

Consumer Satisfaction: Student and instructor contentment with a distance learning medium used to electronically deliver an educational product.

Differences: The degree to which persons or things differ from others (Hauck et al., 1975).

Educational Videoteleconferencing: An electronic technology used in distance learning in which live video and audio are transmitted to provide two-way communication between an instructor and geographically separated students (Benson & Hirschen, 1988; Clark, 1989; Moore, 1989).

Educational Videoteleconferencing Environment: A learning situation in which students are geographically separated from their teachers (Clark, 1989; Moore, 1989). Instruction originates at a distant site from the learner(s) and usually involves two-way electronic

communication by means of interactive audio and/or video (Benson & Hirschen, 1988; Schamber, 1988).

Environment: The aggregate of surrounding things, conditions, or influences (Hauck et al., 1975).

Experience: The knowledge gained from personally observing, encountering, or undergoing something (Hauck et al., 1975).

Gender: The sex a person is; female or male.

Instructor: A teacher, trainer, or educator; one who furnishes knowledge usually by a systematic method (Hauck et al., 1975).

Interactivity: The ability for people to spontaneously communicate with each other.

Live: Broadcasting or transmitting an event at the moment it is being presented (Hauck et al., 1975).

More effective: The electronic distance learning delivery medium that produces better educational results.

One-way: (See "Two-way") Providing information that cannot be immediately responded to.

Two-way: (See "One-way") Providing information that can be immediately responded to; spontaneous interactive communication between individuals or groups.

Video: (See "Audio") The visual elements of television; visuals that are transmitted and received (Hauck, Su, & Stein, 1975).

Operational Definitions

Attitudes: (see "Consumer satisfaction," below).

Student Attitudes: Positive or negative opinions or perceptions regarding either of the two videoteleconferencing systems employed to deliver the instruction during the treatment as indicated and/or noted on the Test and Questionnaire Instrument for Groups A and B

(see Appendix A, items 17-22) in semantic differential scales, a Likert scale, a forced choice item, and two open-ended questions.

Instructor Attitudes: Positive or negative opinions, perceptions, or preferences regarding either of the two videoteleconferencing systems employed to deliver the instruction during the treatment as indicated and/or noted in a personal interview with the instructor conducted by the researcher (see Appendix B).

Cognition: Amount of information the student retained from the instruction in the experiment as measured by a 10-item test (see Appendix A) that included fill-in-the-blank, multiple choice, and true/false items. Each item was worth 10 points for a maximum score of 100.

College students: A convenience sample of 14 Arizona State University students (12 undergraduates and 2 graduate students) enrolled in a 400-level (senior) mass communication course entitled "Cable TV and Emerging Telecommunications." The majority of these volunteer subjects (10 out of 14) had not participated in a videoteleconference before the experiment. There were 7 females and 7 males.

Comparing (Hypothesis): Results of the t-test used to determine if there were any differences in cognition between the two groups of videoteleconferencing subjects as measured by a 10-item test (see Appendix A) that included fill-in-the-blank, multiple choice, and true/false items.

Consumer Satisfaction: (see "Attitudes," above).

Student Satisfaction: Student contentment with the two videoteleconferencing systems used to electronically deliver instruction during the treatment as indicated on the Test and Questionnaire Instrument for Groups A and B (see Appendix A, items 17-22) in semantic differential scales, a Likert scale, a forced choice item, and two open-ended questions.

Instructor Satisfaction: Instructor contentment with the two videoteleconferencing systems used to electronically deliver instruction during the treatment as indicated in a personal interview conducted by the researcher.

Differences:

For Research Sub-question 1: The degree to which the mean cognitive scores from each group varied on the student questionnaire.

For H_1: A statistically significant difference in the cognition scores of each group as determined by a t-test.

For Research Sub-question 2: The degree to which the number and type of interactions observed between the instructor and the students in different learning environments varied as measured by the number and type of student/instructor interactions in each group (Ober, Bentley, & Miller, 1971).

Educational videoteleconferencing: (see also "Educational videoteleconferencing environment," below). Either of two brief lectures on ITFS (Instructional Television Fixed Services) and MMDS (Multiple Multipoint Distribution System) technology presented by an instructor and transmitted live with two-way video and two-way audio (12 minutes long) or one-way video and two-way audio (11 minutes long) to a separate studio/classroom. Students in both groups were able to see, hear, and communicate with the instructor via television monitors, audio monitors, video cameras, and desktop microphones (see Appendix C).

Educational videoteleconferencing environment: (see also "educational videoteleconferencing," above). A distance learning studio/classroom configured for receiving ITFS transmissions in a controlled laboratory setting in the C-Wing of the Business building at Arizona State University (see Appendix C). Two groups of subjects received electronically transmitted video and audio instruction (either one-way video with two-way audio or two-way video with two-way audio) from a distant professor located in a separate studio/classroom. The

instructor could see and hear the first group of 8 students (Group A) but was only able to communicate orally with the 6 students in the second group (the instructor could not see Group B). Both the instructor's classroom and the subjects' classroom were similarly configured. Each studio/classroom had 3 27" television monitors, 3 video cameras, and 2 audio monitors. The students' room had 20 desktop microphones and the instructor's had 22.

Experience: The amount of videoteleconferencing background each student had as indicated on item 16 of the student questionnaire (see Appendix A). Students had three choices:

a. This is my first time in a videoteleconferencing environment;

b. I have participated in at least one videoteleconferencing class or conference but do not consider myself an expert on videoteleconferencing technology;

c. I have extensive experience working with videoteleconferencing technology.

Gender: Male or female, as indicated on item 12 of the student questionnaire (see Appendix A).

Instructor: The teacher of the subjects' regular class, a 400-level (senior) mass communication course entitled "Cable TV and Emerging Telecommunications" at Arizona State University, who presented two nearly identical lectures (one 11 minutes long and the other 12 minutes long) on ITFS and MMDS technology to the two groups of volunteer subjects. The first group of students (Group A) received the instruction via two-way video with two-way audio videoteleconferencing and the second group (Group B) received the instruction via one-way video with two-way audio videoteleconferencing in a controlled laboratory setting in the C Wing of the Business building at Arizona State University.

Interactivity: Amount of communication during the treatment (a 12-minute lecture for Group A and an 11-minute lecture for Group B) between the students and the instructor as measured by the number of oral questions and responses observed in each group of students during the lectures (Ober, Bentley, & Miller, 1971).

Instructor attitudes: (See "Attitudes," above).

More effective: The difference between one-way video and two-way video EVC as measured by a combination of four factors: 1) cognition on the student questionnaire (items 1-10), 2) the amount and type of student/instructor interaction observed in the instructional phases, 3) student attitudes noted on the instrument (items 17-22), and 4) instructor preferences noted in a post-experiment interview conducted by the researcher.

One-way video with two-way audio: (see also "Two-way video with two-way audio," below). A type of videoteleconferencing system in which the Group B subjects received video and audio instruction from the instructor located in another studio/classroom. While the subjects could see and hear the instructor, the instructor could only hear the students. He could not see them. In the two-way video with two-way audio phase of the treatment, the instructor and the students could both see and hear each other.

Student attitudes: (see "Attitudes," above).

Two-way video with two-way audio: (see "One-way video with two-way audio" above). A type of videoteleconferencing system in which the Group A subjects received video and audio instruction from the instructor located in another studio/classroom. Both the subjects and the instructor could see and hear each other. In the one-way video with two-way audio phase of the treatment, the instructor could not see the students.

Scope of the Study

The two most interactive, full-motion videoteleconferencing systems commonly used were directly compared in an experiment in an attempt determine which distance learning technology generates greater cognition as well as evaluate the importance of college-level student/instructor interactivity and consumer satisfaction in a distance learning environment.

Delimitations. Volunteer subjects recruited from a class in the Walter Cronkite School of Journalism and Telecommunication at Arizona State University, constituted a convenience sample.

1) Students were stratified by gender and randomly assigned into two separate groups of 8 and 6 (Group A and Group B).

2) Each group had an equal ratio of males to females to reduce the possibility of bias.

3) Group A received instruction via a two-way video with two-way audio videoteleconferencing system while Group B received instruction via one-way video with two-way audio videoteleconferencing system.

4) Each group received instruction independently from the other in an attempt to isolate the attributes of each delivery system and eliminate distractions for the instructor and the students.

5) The duration of the two instructional phases of the experiment was planned to last approximately 10 minutes each. The first lecture took 12 minutes and the second lecture went on for 11 minutes.

Limitations.

1) The instructor had no prior experience with teaching a videoteleconference course although he had considerable experience working with the technology. The medium may have affected the instructor's performance as the instructor may have been uncomfortable teaching to an empty room in front of video cameras.

2) The majority of subjects had not participated in a distance learning program prior to this experiment. The presence of television monitors, cameras, and microphones in a new instructional setting may have diverted student attention from the content of the instruction. The distractions of the audiovisual hardware, the short length of the instruction, and a limited

amount of time to become accustomed to the situation may have degraded student attention or interest in the content presented (Ritchie & Newby, 1989).

3) The small size of the sample population (n=14) in this pilot study limits generalizing the findings to the overall population of college students.

4) The presence of video cameras, monitors, and microphones may have inhibited student/instructor interaction.

5) Some students may have misstated their Arizona State University grade point average (GPA) on the questionnaire which could have compromised the equality of the two groups. Stephenson (1992-1993) stated that when student ability is not controlled, "inconsistent achievement results should be expected" (p. 32). However, self-reported GPAs were compared with the students' scores from their first class examination of the semester in their normal class and no discrepancies were found.

6) Artificiality is a major concern with any experiment (Wimmer & Dominick, 1991). Students may act or respond differently than they normally would in a typical classroom setting as they know they're being observed. The amount of student/instructor interaction could be affected by the superficiality of a new environment. The brevity (11 to 12 minutes) and clarity of the well organized instruction which included basic overhead charts and outlines may have precluded student/instructor interaction.

7) While each group received parallel or similar instruction on the same material, the instructor could not duplicate the exact timing and presentation of the material for both groups of subjects.

Assumptions.

1) Education instructors and administrators as well as military training organizations have an interest in this research and how its conclusions might be used to make cost-effective procurement decisions regarding educational videteleconferencing systems.

2) Subjects will cooperate, perform to the best of their abilities, and answer the questionnaire honestly.

3) Interaction between students and instructors is important to the learning process. Educators involved with distance learning have stressed its importance (Daniel & Marquis, 1979; Garrison & Baynton, 1987; Holmberg 1983; Smeltzer & Davy; 1987; Threlkheld, 1990); however, various studies about the effects of interaction in televised instruction provided mixed conclusions about the importance of student/instructor interaction (Anderson, 1978; Chu & Schramm, 1967; Cohen, Ebeling, & Kulik, 1982; Perin, 1983; Kataoka, 1987; Weingand, 1984; Wergin, 1986). Salomon (1981) and Clark (1983, 1989) found student performance did not significantly change as a result of the delivery method.

<u>Significance</u>

Although studies have shown distance learning students perform as well as or better than their traditional classroom counterparts (Moore & Thompson, 1990; Stone, 1988), useful information can be gained by comparing the factor of interaction possible with different distance delivery systems. Varying degrees of interaction could be measured and contrasted in terms of student performance and/or attitude towards the instruction (Ritchie & Newby, 1989).

Student and instructor preferences and attitudes about the technology and the instruction styles used in EVC could be used to improve the learning process. Moore et al. (1990) recommended further study regarding which teaching techniques generate the best results in distance education and suggested more research was also needed on how teachers can facilitate greater interaction. According to Barron (1987), a major barrier to distance learning has been unskilled faculty who have not adapted their teaching styles to the technology. Barron (1987) concluded more longitudinal research was needed on teaching styles and modes to effectively evaluate the quality of new delivery systems with traditional ones. In a comparison of one-way video and two-way video EVC systems, Lehman and Kinney (1992) attributed

superior performance by the one-way group to superior training methods (teaching styles), not the technology used to deliver the instruction. They did not elaborate on which types of training methods contributed to superior cognition.

Considerable savings can be realized if there are no significant differences in the posttest scores between the one-way video with two-way audio and the two-way video with two-way audio videoteleconferencing groups. Distance learning organizations could reduce teaching and/or training expenses without a decline in the quality of the education as well as realize significant savings when making equipment procurement decisions. Moreover, even more substantial long-term savings could be realized by transmitting just one multi-directional video signal, which requires less bandwidth than the signals for two-way videoteleconferencing.

Summary

This experimental research was conducted to study the effectiveness of two interactive EVC systems by comparing and evaluating cognitive performance, student/instructor interaction, and consumer satisfaction with each delivery medium. Group A received instruction on a two-way video EVC system and Group B received instruction on a one-way video EVC system.

Considerable savings can be realized if there are no significant differences in effectiveness between one-way video with two-way audio and two-way video with two-way audio videoteleconferencing systems. Useful information can be gained by comparing the factor of interaction possible with different distance delivery systems.

Organization of the Study

This study is organized into five chapters. Chapter 1 introduced the research problem: Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing? Chapter 2 reviews selected literature relevant to the

problem. Videoteleconferencing technology and its applications (commercial, educational, and military) are addressed along with a detailed examination of educational videoteleconferencing. Chapter 3 describes the experimental research design and methodology employed to compare and evaluate the effectiveness of the 2 most interactive full-motion educational videoteleconferencing systems in terms of cognition, student/instructor interaction, and attitudes about the technology. Chapter 4 presents the analyzed data and findings obtained from 4 instruments designed to measure effectiveness: a cognitive posttest, an observation form that measured the amount and types of student/instructor interactions, a student/subject questionnaire measuring satisfaction, and a post-experiment interview with the instructor to determine instructor preference. Chapter 5 discusses the findings and presents conclusions, implications, and recommendations for further study.

Chapter 2

Literature Review

Videoteleconferencing, also called videoconferencing, was initially developed in the late 1950s and early 1960s as a way to electronically conduct business meetings with two-way video and audio between geographically separated groups (Bleazard, 1985; Gross, 1990). The technology has spawned a variety of commercial and military applications, from conducting simple business meetings and sales to training and medical diagnosis. Videoteleconferencing has become a commonplace technology that has enabled universities, community colleges, and public schools to reach previously inaccessible students.

Background information on videoteleconferencing and distance education use of videoteleconferencing will initially be reviewed before addressing videoteleconferencing technology and its applications. A broad look at technology and applications provides a foundation for reviewing various educational videoteleconferencing (EVC) systems employed throughout the United States. EVC effectiveness is explored next, including a review of user perceptions about the technology and student/teacher interactivity issues.

Videoteleconferencing

According to Bleazard (1985), teleconferencing is "...the technique whereby a group of geographically dispersed people can hold meetings or discussions via an intervening communications media..." (p. 11).

Bleazard (1985) explained "A teleconferencing system enables groups of people dispersed over multiple locations to communicate and exchange information dynamically, employing various media..." (p. 11).

Rogers (1986) clarified teleconferencing "as a small group meeting held by interactive electronic communication among three or more people in two or more separate locations" (p.

50). In other words, groups of people at different locations communicate with each other through various electronic means from telephones and computers to fax machines and satellites.

Videoteleconferencing is one of three forms of teleconferencing. Audio and computer teleconferencing comprise the two other forms. Audio teleconferences are normally conducted via the telephone; computers communicate with each other via networks and phone lines. These two types of telemeeting are cheaper than videoteleconferencing; however, audioconferencing doesn't offer the face-to-face interaction possible with videoteleconferencing (Rogers, 1986). In the early 1990s, computer manufacturers began introducing PCs with built-in videoteleconferencing capability (Intel Corporation, 1994; Karpinski, 1991).

Two types of videoteleconferencing have been used; point-to-point and multi-point (Bleazard, 1985; Rogers, 1986). Point-to-point involves only two locations utilizing two-way communication while multi-point disseminates information to more than one group or enables communication between multiple groups. Equipment capability and transmission costs determine how many groups participate (Mathis, 1987).

Although the first videoteleconferencing system, PicturePhone, was introduced in 1957, videoteleconferencing was not initially embraced by the business world as expected. High start-up and operating costs coupled with incompatible equipment delayed the acceptance and growth of videoteleconferencing until the late 1980s and early 1990s (Cotton, 1991). Its true potential received considerable attention under the umbrella of President Clinton's Information Highway. Improved technology resulting in lower bandwidth requirements, cheaper switched digital services, and special phone company incentives were major factors in the emergence of videteleconferencing as a cost-effective technology with seemingly limitless applications (Carter, 1993; Cotton, 1991). According to AT&T, the number of videoteleconferencing rooms in the U.S. increased from 700 in 1988 to 2,500 in 1990 (McAdoo, 1991). Equipment

manufacturer revenues have also risen rapidly, climbing from $58 million in 1988 to $217 million in 1990, with projections of $1 billion in 1995 (Cotton, 1991; McAdoo, 1991).

As mentioned previously, one of the first applications for videoteleconferencing was the business meeting. Participants typically went to a specially equipped conference room that had at least one video camera, microphone, and a TV screen. During a videoteleconference, participants made presentations with graphics, charts, or just about anything a video camera could see. The camera served as the eyes and the microphone with speakers as the ears for those not in the same conference room (Rogers, 1986).

Since its commercial application in the mid-1970s (Bleazard, 1985), videoteleconferencing has evolved into more than just a means of holding an electronic meeting between geographically separated groups (Rogers, 1986). Other innovative applications include teaching, training, introducing new products, and information dissemination. Even the medical field has developed uses for the technology with doctors diagnosing and treating patients via videoteleconferencing ("Good Morning," 1993; Karpinski, 1991).

Distance Education

Videoteleconferencing technology has significantly benefitted distance education--a learning arrangement where teachers and learners are geographically separated (Clark, 1989; Moore, 1989), by providing educators a way to reach previously inaccessible students and working adults without a presumable loss in educational quality. Distance education, a term which originated in Europe, provides opportunities for continuing education to students who are unable to attend conventional courses at formal educational institutions because of distance, cost, time, or physical incapacity (Ely, 1981). Community colleges unable to afford large professorial staffs have brought distant professors and expertise to their students electronically (Barney, 1990). Schools have tapped into established videoconferencing

programs to broaden their curriculum without having to hire additional instructors (Barker, 1987; Benson & Hirschen, 1988; Pirkl, 1990).

In distance education (also known as distance learning), instruction originates at a distant site from the learner(s) and usually involves two-way communication by means of interactive audio and/or video (Benson & Hirschen, 1988; Schamber, 1988). Electronic media or combinations of media are used to bridge the distance gap. Prior to the 20th century, printed correspondence study was the only method available. In the 20th century, telephones and radio initially provided interactive audio communication between the teacher and student followed by television and computer technology in the latter half of the 20th century (Clark, 1989).

Distance learning has grown at all levels of education in the U.S. and abroad (Kruh & Murphy, 1990). Canada, Australia, Europe, and Russia as well as many developing countries have developed and participate in distance education programs (Schamber, 1988). Rapid technology developments have led to new delivery methods. One promising development has been the adaptation of the personal computer (PC). Both AT&T and Northern Telecom have developed and tested PC videoconferencing systems. AT&T's project involved presenting course work, including voice, data, and video on the PC. The products were designed to allow schools to share limited resources (Karpinski, 1991). Now that desktop systems like these have become possible, the Air Force believes the PC could develop the largest videoteleconferencing audience (Headquarters Air Force C4 Agency, 1995).

Videoteleconferencing Technology and Cost

Before 1985, most videoteleconferencing was done on analog, wide-band transmission technology--the same system used by U.S. television broadcasters. Technology developed in the early 1980s enabled analog video imagery to be digitized and compressed into a much smaller or narrower bandwidth commonly called compressed-motion video (Bleazard, 1985). Unfortunately, image quality was compromised.

Signal bandwidths were compressed to reduce the high cost of transmitting full-motion video. The cost of transmitting full-motion video has been significantly higher than transmitting compressed-motion video. According to E. A. Craft (personal communication, September 13, 1993), Director of Distance Learning Technology in the College of Extended Education at Arizona State University, full-motion service cost $470 per hour on the KU band on a satellite transponder in 1993. With improved digitization and compression technologies, transmission costs had been reduced by as much as 50% in the mid-1980s (Bleazard, 1985). In 1991, MCI Communications customers paid a mere 15.7 cents per minute for low quality compressed-motion videoconferencing or a $1.10 per minute for high quality compressed-motion videoconferencing service (Cotton, 1991).

The unavailability and high cost of wideband transmission circuits and satellite transponders needed to receive and send full-motion video hampered the acceptance of videoteleconferencing in the 1970s and early 1980s (Bleazard 1985). Prior to the first commercial use of compressed-motion video in 1990 (Carter, 1993), the best way to reduce transmission costs was to hold large or special event conferences. Large audiences could share the expense (Bleazard, 1985). But this type of meeting had to be planned well in advance. A broadcast TV studio had to be booked, participant schedules arranged, and technicians hired in addition to coordinating many other essential actions. The inconvenience of having to travel to the nearest public studio was another drawback. This lack of easy access coupled with the high cost of building and operating private videoteleconferencing facilities constricted the growth of wideband videoteleconferencing (Bleazard 1985). In the early 1980s, the typical videoconference room with equipment cost $500,000 while transmission service averaged $15,000 per month for a full-time circuit (Cotton, 1991).

Costs have tumbled since then. Customers willing to settle for black and white visuals with limited motion could purchase a videoconferencing system for less than $20,000 in 1991.

Color systems with "near-broadcast quality" averaged between $25,000 to $50,000 per location (Cotton, 1991; Thompson, 1991). Equipment can also be leased. In 1991, AT&T charged customers $5,000 to $7,000 a year--roughly the cost of leasing a photocopying machine (Thompson, 1991).

With reduced equipment and transmission costs, computer manufacturers began developing PCs capable of transmitting and receiving video imagery via phone networks in the early 1990s. In 1993, Intel Corporation--one of the largest microprocessor manufacturing companies in the world, and MCI Communications announced they had reached an agreement to develop ways to integrate the PC and the telephone. The product they plan to produce, an add-on circuit board that fits into the PC, would enable PC users to simultaneously transmit data, audio, and video over phone lines ("Intel, MCI," 1993).

In 1994, manufacturers introduced PC-based videoconferencing systems. Intel Corporation introduced a concept called personal conferencing aimed at the business community, and Alpha Systems Lab Incorporated introduced the industry's first mobile videoconferencing solution (Intel Corporation, 1994; Medrano, 1994). According to Intel, personal conferencing can be as interactive as the customer needs it to be. Users can transmit documents and conduct audio and video conferencing if necessary directly from their desktop computers. With the launch of Indeo compression/decompression technology, Intel was able to reduce the amount of bandwidth and data being transmitted--making PC videoconferencing a cost-effective reality (Intel Corporation, 1994). Mobile MegaConference broke new ground with a multimedia video card that enables computer users to videoconference from virtually any location that has access to regular phone lines. Both the Intel and Alpha Systems Lab videoconferencing systems rely on compression technology. As with the development of compression equipment for non-PC based videoconferencing, PC manufacturers have not been able to agree on compatible standards which

would facilitate interoperability with different PC based videoteleconferencing systems (Headquarters Air Force C4 Agency, 1995).

Analog -vs- digital (compression). The key to the widespread integration of videoconferencing in the U.S. has been the development of improved digital compression technology (Cotton, 1991). As mentioned earlier, two types of video signals are used in videoteleconferencing broadcasts: analog and digital (compression). Analog signals are non-digital, full-motion video signals. Because analog video requires significantly greater bandwidth, compression algorithms were developed to reduce the amount of bandwidth needed for transmission. In a typical compression process, an analog or broadcast quality video signal from a video camera is digitized using special equipment so it can be squeezed or compressed into a much smaller bandwidth for transmission to other locations; the lower the bandwidth the lower the transmission cost (Baldwin & McVoy 1988; Bleazard, 1985).

A wide range of compression ratios has been developed to reduce transmission expense (Goldberg, 1993). Transmission speed is proportional to the bandwidth or space the signal occupies: the slower the transmission rate the smaller the bandwidth. Faster speeds equate to wider, more expensive bandwidths but also provide improved visual quality. Bandwidth is important because the normal telephone line can't accommodate signals greater than 3 Kilohertz (KHz; thousand cycles per second) (Carter, 1993).

For comparison, an NTSC signal (the U.S. color TV broadcast standard adopted by the Federal Communications Commission in 1941 created by the National Television Standards Committee--a private organization) requires an information transmission speed of about 90 million binary digital bits per second (90 Mbps), which roughly equates to a 6 Megahertz (MHz; million cycles per second) bandwidth (Carter, 1993; Sterling & Kittross, 1978). Digital videoteleconferencing operators could initially transmit at speeds of 1.5 and 2 Mbps, which roughly equaled 1.5 and 2 KHz in bandwidth respectively. This significant reduction

translated to compression ratios of 66:1 and 50:1 respectively (Bleazard, 1985). In 1993, a user could transmit "standard video" at 112 Kilobits per second (Kbps) or "enhanced video" at 336 Kbps (Masud, 1993), which reflected a reduction from the millions to mere thousands. By 1993, transmission costs had plummeted to as low $30 per hour (Masud, 1993).

Codecs and compression techniques. Microprocessors called codecs (short for coder-decoder) are used at both the transmission and receiving sites to digitize as well as compress and decompress video signals (Bleazard, 1985, p. 88). A codec takes an analog video signal (the picture), converts it to digital form, compresses it, and transmits the new digital signals via phone lines, microwave, cable, or satellite to another site equipped with another codec that continuously deciphers the signal (Bleazard, 1985; Fizer 1993; Masud, 1993). Goldberg (1993) likened the digitizing process "to a photograph being projected through a fine screen, and each tiny square in the resulting mosaic or bitmap being assigned a value of 1 or 0 for 'on' or 'off'" (p.101).

Once an analog signal has been digitized, codecs use any or all of five compression techniques to reduce or compress the signal (Bleazard, 1985, pp. 88-89). All five designs represent a compromise in resolution quality compared to full-motion, analog, broadcast signals. The five compression techniques are:

1) Field or frame elimination,

2) Intraframe methods,

3) Interframe methods,

4) Mathematical transformations, and

5) Motion compensation.

In field or frame elimination, a codec at the sending site eliminates frames of video to reduce bandwidth. Another codec at the receiving location decodes and reconstructs the missing frames by repeating the previous frame.

Intraframe methods eliminate redundant visual information within a frame or between frames. For example, if a blue background is in every frame, the codec can use less information bits to code and decode. It only has to transmit the blue background once.

With interframe, the current frame is compared with the one before it to identify areas in the picture that change. As a result, only the differences are transmitted.

Mathematical functions or complex algorithms are used to represent the picture as well, further reducing the number of bits that need to be transmitted.

Instead of comparing single frames, motion compensation quickly stores a series of frames to predict the motion likely to be present in the next frame.

Of necessity, many videoteleconferencing rooms are configured with bland backgrounds, which allows the codec to concentrate on the talking head. Because the codec doesn't have to continuously transmit the background, less bits of information need to be transmitted. According to D. A. Fizer (personal communication, September 10, 1993), director of Air Force Videoteleconferencing at Scott Air Force Base, Illinois, quality has become quite good. Fizer said the visual quality gap between full-motion and compressed-motion video has been narrowed.

Compatibility. Codec non-standardization, a major problem in the early 1980s, has continued despite quantum leaps in codec technology. Early codecs in the 1980s could only operate at one factory preset speed on either the European PAL or American NTSC technology standards (Bleazard, 1986). Manufacturers had independently developed codecs hoping theirs would become the standard. Competing codecs couldn't "talk" to each because they didn't operate at the same speeds or in the same video format. Compatibility was still the biggest obstacle inhibiting the acceptance of compressed-motion videoconferencing in 1993 (Carter, 1993).

Codec manufacturers have attempted to meet various interoperability standards adopted by the CCITT (Consultive Committee for International Telephones and Telegraphs), MPEG

(Motion Picture Experts Group), and SMPTE (Society of Motion Picture and Television Engineers), to name a few (Bleazard, 1985; Carter, 1993; Fizer, 1993). Unfortunately, none of these standards has kept pace with continuing technological developments. By the time a standard is approved, it is already outdated (Carter, 1993). As a result, many organizations that use videoteleconferencing haven't upgraded.

Despite continual compatibility problems, many organizations have pushed ahead with digital videoteleconferencing systems (Carter, 1993). The threat of terrorism during the Gulf War in 1991 prompted many companies to explore the videoconferencing alternative to potentially dangerous air travel. Once companies discovered the travel savings possible with videoconferencing they incorporated the technique for the long run. They also learned that videoconferencing reduced the length of meetings by "forcing speakers to be concise, presenters to be brief, and arguments to be truncated" (Thompson, 1991, p. 51). These savings and benefits outweighed the negative factors of reduced image quality and compatibility.

In an attempt to remedy the problem of incompatibility, many equipment manufacturers began producing updatable equipment in the early 1990s (Thompson, 1991). In the past, buyers had invested heavily in hardware that was quickly obsoleted. With the advent of interchangeable computer chips and boards in the late 1980s, videoconferencing customers have been able to update their systems by replacing the chips and boards similar to the way desktop computers are upgraded. Innovations like these along with improved software have made different videoteleconferencing networks compatible (Thompson, 1991).

Industry leaders have been pushing for a lasting compression standard. Carter (1993), Engineering Manager for Distance Learning Technology at Arizona State University, reported, "There are several large players in the market today who will drive us all towards a common standard" (p. 4). He listed the broadcasters, cable companies, and the Federal Communications Commission (FCC) as the key organizations. With its projected emergence in 1996, High

Definition Television (HDTV) may also present a new standard. Four of the 5 HDTV systems employ compression technology to transmit their signals (Carter, 1993). One reason the majority of HDTV manufacturers employ digital compression is that full-motion HDTV transmission bit rates are more than double the NTSC full-motion video bit rate of 90 Mbps (Carter, 1993).

Delivery Systems and Educational Videoteleconferencing

Delivery systems that have been utilized in commercial videoteleconferencing have also been used to facilitate EVC. In general, EVC has utilized five different delivery systems or mediums: phone lines, cable, microwave, satellite, and fiber optics. When properly used, these technologies facilitate live interaction--spontaneous feedback between teachers and students. They have been used to simulate the traditional classroom environment. Varying degrees of interactivity are possible with these delivery systems, which are rank-ordered from most to least interactive below (Barker, Frisbie, & Patrick, 1989, p. 22):

1) Full-motion two-way video and audio links,

2) Freeze frame two-way video and audio links,

3) Full-motion one-way video with two-way audio links, and

4) Freeze frame one-way video with two-way audio links.

Phone line delivery. Phone lines are limited by the amount of information they can carry. Audioteleconferencing has been employed when the higher cost of establishing and operating videoconferencing facilities was not justifiable. Codecs are needed to digitize and compress video to conduct videoteleconferences via phone lines (Carter, 1993; Fizer, 1993). As mentioned earlier, compressed, full-motion video quality has improved but does not quite measure up to full-motion analog imagery transmitted via microwave, cable, satellite, and fiber optic cable (D. A. Fizer, personal communication, September 10, 1993). However, the

telephone has been used in conjunction with satellite, microwave, fiber, and cable systems to improve interactivity between students and instructors (Kruh & Murphy, 1990).

Cable delivery. Cable offers innovative interactive communication opportunities for adult education (Benson & Hirshen, 1988). Most cable systems built after 1972 have full-motion two-way video with two-way audio capability (Baldwin & McVoy, 1988) which allows for interaction among subscribers, schools, and corporations. With cable delivery, distance education students can take courses in the comfort of their home. In an automated interactive instructional system, home students log on and off and receive immediate feedback when responding to questions. During a live lecture, the instructor can monitor aggregated student responses and make instant adjustments to improve the instruction (Baldwin & McVoy, 1988).

Students participating at corporate or public sites connected to institutional (two-way) cable get the added benefit of visual interactivity (Baldwin & McVoy, 1988). The instructor can actually see these students. Institutional networks provide a low-cost means of distributing live presentations (Baldwin & McVoy, 1988). No towers have to be built and government grants are unnecessary because cable systems are already in place (Benson & Hirshen, 1988).

American Cablesytems of Ossining, New York, established a pilot cable connection between two schools in 1988. The cable company provided two access channels, monitors, cameras, and microphones to give the schools two-way video and two-way audio EVC capability. Benson and Hirschen (1988) reported students did very well but did not provide specifics or elaborate on the goals of the project. The success of the project led American Cablesystems to voluntarily wire all of Ossining's high schools to form a closed loop network (Benson & Hirschen, 1988).

Microwave delivery. Microwave technology delivers both video and/or audio communication point-to-point and by line-of-sight (Lamberti, 1992). Both the business arena and education community have used microwave technology to reduce videoconferencing

expenses. This electromagnetic delivery system is easily installed compared to the time and cost needed to install cable. Additionally, monthly common carrier line charges are unnecessary when microwave is used (Lamberti, 1992).

Remote classroom links allow students at work and on various campuses to simultaneously view the same lecture (Lamberti, 1992). In New York, a microwave system linked the two campuses of Houghton College, which are 65 miles apart. The college saved over $2,000 per month by using the system for long distance telephone calls between the campuses. The money saved offset the operating costs of the microwave system (Benson & Hirschen, 1988).

Many campuses have licensed permission to broadcast telecourses via the Instructional Television Fixed Service, commonly known as ITFS. ITFS broadcasts one-way video and audio over a radius of 25 miles on FCC designated microwave frequencies specifically dedicated for educational use (Schamber, 1988). Any location with the appropriate antennae and television equipment can receive audio and video signals from an ITFS affiliated school. Because ITFS is one-way, full-motion video and audio communication, additional technologies like the telephone are used in tandem to facilitate student/teacher interactivity (California State Postsecondary Education Commission, 1987).

ITFS stations have been located in or near big cities primarily benefitting large schools. However, smaller rural schools close to a metropolitan area with ITFS can use the signal as well. In 1987, the Region IV Education Service Center in Houston operated the InterAct Instructional Television Network via ITFS. Video and audio signals were dispersed via omnidirectional microwave signals to subscribing receivers in seven counties along the Texas Gulf coast. More than 30 schools subscribed to the network that provided high school courses, K-12 student enrichment viewing, staff development, and college courses for credit. Receiver

classrooms were equipped with specially modified television sets and talk back instruments (Barker, 1987a).

Satellite delivery. Communication satellites orbiting at a fixed position 22,300 miles above the earth receive microwave signals on a set frequency from a federally licensed uplink dish to beam the video and audio signals back down to individual backyard dishes and earth stations (Benson & Hirshen, 1988; Schamber, 1988). While satellites have enabled organizations to communicate with groups across the country and around the world (Baldwin & McVoy, 1988), transmission prices have been significantly higher than telephone line transmission rates. In 1991, satellite transmission prices between two sites averaged around $2,000 to $3,000 per hour compared to $300 to $450 per hour for telephone line and fiber optic cable transmission (Thompson, 1991). More than 600 schools in the United States operated satellite dishes in 1989 (Clark, 1989).

Alaska was one of the first states to utilize satellite technology for education. The LEARN/Alaska Instructional Television Network, established in 1981, provided educational programming to 250 remote sites spread out across the largest state in the union. Educational programming was made available to nearly every resident from kindergarten through college (Benson & Hirshen, 1988). However, LEARN/Alaska was discontinued in 1988 as funding for the program provided by Alaska's oil industry was cut-off as a result of declining oil revenues (Clark, 1989).

Many other states have since developed educational videoteleconferencing networks. In 1988, more than 200 Texas public schools along with schools in 17 other states were electronically connected via satellite by the privately-owned TI-IN Network in Texas to receive educational and staff development programming (Benson & Hirshen, 1988).

Fiber optic delivery. Fiber optic lines are very thin strands of glass designed to carry audio, video, and data signals. With fiber, the need to compress video signals is unnecessary

because fiber optic cables can carry 32,000 times more telephone traffic than conventional copper wire at faster speeds with improved quality (Gross, 1990; Maslowski, 1994). However, fiber-based technology is expensive to install when compared to using in-place cable, phone lines, or microwave (Kruh & Murphy, 1990).

Although cable and phone line delivery systems have been acceptable, they don't offer the ability to duplicate a normal classroom the way digital fiber can. Digital fiber picture-quality does not degrade over long distances as it does with other delivery technologies. An additional benefit of digital fiber is its ability to act as a multiplexor--combining digital video with other digital signals, such as computer data and facsimile information (Kruh & Murphy, 1990).

In 1989, the University of California's Chico campus successfully originated interactive video via a fiber optic network to other schools throughout the state (Clark, 1989). Oklahoma and Mississippi also established successful fiber optic videoconferencing networks in rural school districts to save money, keep rural schools open, and provide isolated students a broader curriculum (Kruh & Murphy, 1990). Philip Knight, Superintendent of Schools in Oklahoma, praised the utility of videoconferencing with fiber optics:

> One of the essential things for school districts is to have local control of curricula. Satellite networks didn't offer a full complement of classes. Now we control our curricula and provide classes that meet our specific needs. (Kruh & Murphy, 1990, p. 19)

Fiber optic cables form the backbone of the Iowa Communications Network (ICN), spanning 3,000 miles to link 125 sites across the state. Established in the fall of 1993, ICN is primarily an education network in which students can interact with a teacher in any of the state's 99 counties via two-way video and audio. The 114 million dollar network has carried special guest lecturers like U.S. Attorney General Janet Reno and Iowa Governor Terry Branstad. Telemedicine, computer data, library services, and Internet links have also been carried on the

versatile network. Governor Branstad said the network was "an investment that will pay dividends in terms of excellence in education, governmental efficiency, and economic growth opportunities" (Maslowski, 1994, p. 14).

Cost Effectiveness

Videoconferencing costs have been compared to those of traditional delivery when evaluating cost effectiveness. Potential savings from reducing travel expenses and the possibility of increased enrollments are other basic factors that have been considered when evaluating the cost effectiveness of videoteleconferencing (Moore et al., 1990).

For KMart Corporation, one of the largest retail chains in the U.S., videoconferencing has produced two benefits. In addition to reducing travel costs it enabled company executives to efficiently communicate with their staff at 2,250 Kmart retail stores throughout the country. The company saved $225,000 in travel expenses in 1991 when it switched to videoteleconferencing to conduct company training and information seminars (McAdoo, 1991).

Moore et al. (1990) found that numerous models have been developed to help organizations select the right media based on budgetary concerns. Several studies (Christopher, 1982; Ellertson, Jolley, & Wydra, 1987) have generally confirmed that distance education technology, when effectively employed, is less expensive than conventional classroom instruction. A two-year cost comparison study between the Teleteach Expanded Delivery System (TEDS) and resident instruction for Air Force students at remote sites revealed a savings of $993,841 (Christopher, 1982). Conversely, in a national survey on the cost effectiveness of distance learning in schools, Ellertson et al. (1987) found that only 15 of the 34 classes measured showed the cost per student for distance taught instruction was lower than conventionally taught courses. But it was also noted, in most cases, that the classes would not have been offered in a traditional setting.

With extremely large audiences, videoteleconferencing has become very cost effective. In 1990, the Emergency Education Network (EENET)--the world's largest one-way video, two-way audio, satellite-distributed videoconferencing system with over 120,000 viewers delivered training and instruction to 14,000 locations at a cost to the federal government of less than 12 cents per student hour (Marshall, 1991).

Ellertson et al. (1987) listed seven recommendations for improving cost effectiveness: 1) reduce transmission costs by using voice/data modems, dedicated lines, call-forwarding, and toll-free lines; 2) increase the number of receiving sites; 3) increase the number of courses taught per day; 4) use paraprofessional monitors at remote sites instead of teachers; 5) increase the number of participating students; 6) reduce start-up costs by using audiographics (a combination of two-way audio and some kind of graphic image transmitted via telephone lines) instead of microwave transmission; and 7) lower teaching costs by also having students at the originating site with the instructor.

Barriers

According to David (1994), technology's potential for revolutionizing education has not been realized despite technology's rapidly increasing power, portability, connectivity, and decreasing costs. David said the primary reason technology has failed to live up to its promise is that the majority of technology purchases and uses have been attempts to increase the efficiency of current practices instead of transforming teaching and learning. Choices about instructional hardware and software have been based on whether the new technology could increase standardized test scores. Vendors have purposely demonstrated and stressed the compatibility of their technologies with existing curricula and tests to increase sales. Another problem with implementing new educational innovations is the lack of attention paid to preparing teachers and administrators to use the new technology and determining their preferences about hardware and software (David, 1994).

Rogers (1983) said the diffusion of innovations or technologies, even those with obvious advantages, is often very difficult. An innovation, according to Rogers (1983), is an idea, practice, or object perceived by the individuals who intend to adopt it as new and beneficial. Diffusion is a process by which an innovation is communicated over time to members of a social system. Adoption rates--the relative speed or time it takes an innovation to be adopted--have been faster when the innovation is perceived as useful and compatible. Another factor, which is more difficult to measure, is the impact a particular social system has on the diffusion of an innovation. Different societies with different communication structures have different rates of adoption (Rogers, 1983).

In a 1984-85 attitudinal assessment survey of the American Library Association (ALA), Barron (1987) rank-ordered several barriers to the effective use of educational video technologies. Barron's sample included 57 chairpersons from ALA-accredited Curriculum Committees and programs associated with the Association for Library and Information Science Education. The number one barrier was inadequate finances to purchase videoconferencing hardware and software. A lack of course-ware meeting school academic needs and standards was second on the list. Another barrier was overcoming logistical complexities--how to set up and operate the technology. The number four barrier was faculty who don't have the skills to make use of the technologies. Rounding out the top five barriers was the lack of adequate rewards and incentives to encourage teachers to get involved with the technologies (Barron, 1987).

Barron (1987) concluded more longitudinal research was needed on teaching styles and modes to effectively evaluate the quality of new delivery systems compared to traditional ones. Although there is no perfect electronic medium or teaching model or style for every student, information transfer and learning can be facilitated by determining the optimal teaching mode and style for each technology (Barron, 1987).

Distance Learning and Training Applications

Despite these barriers, distance learning has nevertheless grown at all levels of education in the U.S. and abroad (Kruh & Murphy, 1990). EVC has experienced phenomenal growth since 1983 when fewer than 20 educational conferences were held per year. Up to 40 videoteleconferencing programs per month were available nationwide from more than 20 different sources in the 1989-90 school year (Pirkl, 1990). The following school year, nearly 300 community colleges participated in live satellite videoteleconferences that delivered nationally prominent speakers, not normally available to community colleges (Pirkl, 1990).

Barron (1987) identified several factors responsible for this growth. They included declining enrollments, growing adult populations who are changing careers and seeking new or additional degrees, and the critical need for continuing education.

Aside from electronically bringing national speakers and experts to campus, videoteleconferences bring the business community to the students, help build a college/business relationship, and provide quality staff development. Pirkl (1990) reported audience surveys, taken over a four-year period at Portland Community College, Oregon, indicated 50% to 80% of some audiences had never been on campus prior to attending a videoteleconference. Local businesses have promoted and sponsored many videoteleconferences while the Community College Satellite Network and AACJC have presented several programs addressing professional community college development (Pirkl, 1990).

Community college applications. Pirkl (1990) found community colleges appreciate the value of videoteleconferencing and have taken steps to improve the process by "integrating telephone interaction, pre-taped special segments, and high quality visual aids" (p. 26).

Numerous community colleges participate in national videoteleconferencing and virtually all that do have conducted local "wrap-around" sessions to personalize the learning sessions. In a "wrap-around," prominent community leaders, faculty, and local experts share

their views upon conclusion of the videoteleconference to help personalize and localize the subject. Pirkl (1990) reported audiences showed higher satisfaction when "wrap-around" sessions were added (p. 26).

Rural applications. Small rural schools have traditionally had difficulty attracting teachers, especially in math and science. Remote schools have been hard-pressed to deliver conventional education because of widely scattered student populations. In searching for a solution to teacher shortages and low student enrollments, rural schools were among the first to use telecommunications technology as an educational tool (Barker, 1987; Benson & Hirschen, 1988). EVC and other distance learning technologies have allowed rural schools to offer a full and varied curriculum and conduct quality in-service teacher training without having to consolidate schools and physically transport teachers to each school (Barker, 1987a).

In the fall of 1986, Eastern Washington University and Education Service District #101 in Spokane, Washington, started the Satellite Telecommunications Educational Programming Network (STEP). Similar to the TI-IN Network mentioned earlier, STEP broadcasted live programs four days a week. This gave school officials every Friday time to deal with any student concerns. The STEP Network originally offered just 4 classes but has since added 3 more along with in-service teacher training. By 1987, the network had spread to several northwestern states (Barker, 1987).

Military applications. The Department of Defense has begun to realize new capabilities and considerable savings with digitally compressed videoteleconferencing in a number of training and information dissemination (communication) applications. According to the Air Force Director of Videoteleconferencing, D. A. Fizer (personal communication, September 10, 1993), the military's biggest benefit has been "the timely dissemination of information." Other military benefits include increased productivity, decreased personnel fatigue, reduced

man-hours lost in travel, and less time executive staff members spend away from their offices (Headquarters Air Force C4 Agency, 1995).

Videoteleconferencing has been utilized in military exercises "to shorten the decision making process." Intelligence has become a big user. Numerous bases have set up intelligence sharing systems while others are planning to join established networks. As far as savings go, Fizer (personal communication, September 10, 1993) said, "It's hard to quantify the savings," but just about everyone agrees the military can save money by eliminating unnecessary travel.

For many, videoteleconferencing has become synonymous with distance learning. In the military, that translates to training. The Joint Warfare Center (JWC) at Hurlburt Field, Florida, has employed videoconferencing since 1990 to support wargame simulation for joint training between the services. Videoteleconferencing was first used in an exercise called Internal Look '90 in 1990 for the U.S. Central Command (CENTCOM) immediately prior to their deployment to Operation Desert Shield in Saudi Arabia (Maslowski, 1993).

VTC complemented the ongoing joint exercise enabling deployed staffs to visually communicate with the CENTCOM staff, including Commanding General H. Norman Schwarzkopf (Maslowski, 1993). Videoteleconferencing electronically brought three separately deployed exercise staffs together for 10 days to help improve command, control, and communication (Maslowski, 1993).

The JWC used portable PC-based videoconferencing equipment manufactured by VideoTelecom in Austin, Texas. This included compression capability, dual monitor systems, and a multi-switching unit. Panasonic video cameras were used to look at speakers, maps, and graphic displays while an Elmo document camera provided additional details of slides, photographs, and other graphics. The systems can be plugged into any terrestrial T-1 circuits.

The circuits are encrypted to provide secure communication links for up to six locations simultaneously (Maslowski, 1993).

In 1992, the JWC participated in Roving Sand '92, a training exercise that integrated Air Force, Army, Marine, and Navy command and control systems with associated air defense artillery and aircraft elements. Videoteleconferencing units were deployed to several locations in the Southwestern United States to provide exercise debriefings for geographically separated pilots to instantly share tactics and lessons learned. None of the participants had to be bussed to a central location, thus saving time and travel costs. The money saved enabled some pilots to fly additional training sorties the same day (Maslowski, 1993).

The principal goal of Air Force distance learning has been to "provide quality education to a broader geographically separated student base worldwide" (Headquarters Air Force C4 Agency, 1995, p. 5). The Air Force Institute of Technology (AFIT), which provides graduate degree programs in both technical and non-technical advanced degree programs, has vigorously pursued educational videoteleconferencing as a way to improve education within the Air Force. AFIT established its first distance learning network in 1990 using fiber optic cable. The course, taught by the Air Force School of Engineering, reached six locations and 120 registered students (Fizer, 1993) Three years later in mid-1993, AFIT negotiated with AT&T to establish its own digitally compatible network because many Air Force bases operate older, non-standard codecs (Fizer, 1993).

AFIT worked closely with the National Technological University, a consortium of 44 universities offering distance learning engineering programs, to reduce satellite transmission costs. In 1991, NTU secured a $1.5 million government grant to convert from analog video transmission to compressed digital video. A provision of the grant called for AFIT to participate in a test of the system, which was completed in 1992. In a separate but related action, AFIT purchased NTU membership and installed NTU equipment at 18 bases (Fizer, 1993). The Air

Force discontinued its NTU membership in 1993 when the Air Technology Network (ATN) was established--a video teleseminar technology incorporating one-way compressed video with two-way audio for student/instructor interaction. ATN initially offered a variety of instructional programs including courses in logistics, field training development, and civil engineering. In January 1995, ATN reached 297 sites including every Air Force Base, Air National Guard Station, and Army Post (H. Meyers, personal communication, February 6, 1995). However, the Air Force Reserve subscribed to the Army Training Network--a satellite-based compressed two-way video with two-way audio delivery system. Although different, the Army Training Network has provided the reserve forces the capability to conduct both training and conferencing with existing Air Force and Army videoteleconferencing systems (Headquarters Air Force C4 Agency, 1995).

Arizona State University applications. The use of EVC by a major university can be illustrated with an in-depth review of how one such institution--Arizona State University--has embraced this technology. According E. A. Craft (personal communication, September 13, 1993), Director of Distance Learning Technology in the College of Extended Education, Arizona State University utilizes a variety of delivery technologies including ITFS, cable television, public television, satellite, and microwave. These technologies conveniently allow students to view televised classes at home, work, or special off-campus sites eliminating the need to commute to the main campus.

The university's distance learning telecampus program operates four studio/classrooms, with three cameras per classroom. Television signals from these classrooms are transmitted via fiber optic cable across campus to Stauffer Hall. From there, the ITFS signals are beamed (via microwave) to South Mountain for telecast to the Phoenix metropolitan area. Craft said one camera is mounted overhead to get close-up shots of what the instructor writes down on a pad (instead of a chalkboard) while the other two cameras provide

imagery of the professor and classroom. The cameras are remote controlled and electronically switched by a technician in a control room. Every student in the studio/classroom has access to individual desktop microphones that enable outside viewers to hear student questions. Students at corporate sites or at home can phone in any questions they have to the professor. Both the professor and the students in the studio/classroom hear the calls on a speaker phone.

In the spring of 1995, according to the Arizona State University (ASU) Extended Campus Catalog, ASU offered 56 videoconferencing courses broadcast via the analog ITFS network. Courses were beamed to 21 corporate and 2 public sites, Dimension Cable (Phoenix's largest cable operator), and several ASU dormitories. Craft (personal communication, April 3, 1995) reported that 1,659 students had signed-up for 4,747 credit hours in the 1995 spring semester from ASU's College of Extended Education via television.

The university operates two other videoconferencing systems as well. In 1991, ASU contracted with AT&T to establish a digital microwave link between the main university and its west campus. Since then, the system has added several sites and is now called NAUNet. It transmits two-way video and audio via a two-way microwave circuit that enables both professors and students to see and hear each other. NAUNet has spread throughout Arizona and includes sites at Northern Arizona University in Flagstaff, the University of Arizona in Tucson, Kingman, Holbrook, Yuma, and several other locations in Phoenix and Tucson. Additional sites are expected to join the network in the future (Arizona State University College of Extended Education, 1994).

Coincidently, ASU has been a contributing member of NTU--the same non-profit videoconferencing consortium AFIT joined. In 1993, the NTU digital network offered a number of graduate engineering degrees at over 250 corporate sites nationwide (E. A. Craft, personal communication, September 13, 1993). With NTU, students don't have to leave their work site, and, because it is a digital video signal, the university can reduce 8 channels to 1. A third

digital videoteleconferencing system is used by the board of regents to conduct business with Arizona's two other major universities--Northern Arizona University and the University of Arizona (E. A. Craft, personal communication, September 13, 1993).

The cognitive effectiveness of ITFS delivered instruction at ASU appears to be comparable with traditional classroom education. In 1993, Craft (personal communication, September 13, 1993) said the grade-point averages of students participating in EVC classes mirrored those of their counterparts who attend campus classes in person.

Craft (personal communication, September 13, 1993) preferred broadcast quality (analog) EVC to digital when cost is not a factor but acknowledged digital has become more popular. With digital compression technology, EVC costs have been reduced. Upon converting to digital transmission in 1992, NTU projected annual savings of $1.2 million (Carter, 1993).

Distance Learning Effectiveness

K-12 learner effectiveness. Research on distance education learner effectiveness is scarce, especially for K-12 schools. Available information consists mainly of case studies, opinions, and advice (Moore et al., 1990). The majority of documents found on distance education technology involved applications and benefits, not the general effectiveness of the process. Eiserman and Williams (1987) investigated 503 documents dealing with distance education and found little or no empirical evidence to support claims of general effectiveness. Yet every report claimed positive results by defining effectiveness in a variety a ways. Some said the courses wouldn't have been offered traditionally or cited the cost effectiveness of the program. Others reported how diversity benefitted the students' educational experience. Cognitive and/or skill gains and how teacher work loads were reduced were also mentioned (Eiserman & Williams, 1987).

Preliminary research prior to 1990 indicated distance learners performed as well as or better than their counterparts (Moore et al., 1990). In a study comparing Iowa's two-way

interactive television (TWIT) project, Nelson (1985) found no significant differences between TWIT student grades and those of students taught face-to-face by the same teacher. However, the majority of K-12 distance learning projects have targeted "gifted" learners (Moore et al., 1990). Further research will need to evaluate mainstream and slower learner achievement with distance learning technologies. The impact of variables such as personality and socio-economic characteristics also require investigation (Moore et al., 1990).

Adult learner effectiveness. Numerous studies (Bajtelsmit, 1990; Bruning, Chute, & Hulick, 1984; Delbeq & Scates, 1989; Moore & Thompson, 1990; Sounder, 1993; U.S. Congress, 1989) have been accomplished comparing the effectiveness of adult educational videoteleconferencing with traditional face-to-face instruction. A variety of adult populations were tested, including: undergraduate and graduate students, medical and military personnel, elementary school teachers, laboratory subjects, and others. Content areas like finance, library science, psychology, and mathematics were also evaluated. Every study concluded that teleconferencing delivered effective educational programming (Moore et al., 1990).

In 1984, Bruning, Chute, and Hulick determined that students taught by teleconference (electronic conference board with two-way voice and graphics) learned as well as, if not better than students taught face-to-face. Both groups were pretested and obtained similar scores with no significant differences. Course material was identical for both groups yet the teleconference group's posttest scores were significantly higher than the traditional group's (Bruning, Chute, & Hulick, 1984).

Nine years later, Sounder (1993) directly compared the test scores of distance learners against traditional learner scores in a "natural experiment" he conducted to determine the effectiveness of distance learning compared to traditional classroom instruction. A natural experiment is not a designed laboratory experiment, but one that presents itself by virtue of circumstances (Hill, 1970; Kerlinger, 1986; Lee, 1989). Sounder decided to conduct the

experiment when he was asked to teach the same graduate-level course for three different universities: the Georgia Institute of Technology (GaTech), the University of Alabama in Huntsville (UAH), and NTU.

Average student ages and work experience varied with each institution. NTU students were older and had far more work experience than UAH and GaTech students. These statistics were significant in Sounder's findings and conclusions. He taught the NTU videoteleconference at a GaTech studio in which GaTech students attended in-person. NTU students communicated via telephone with the professor during the live instruction. Sounder then returned to teach the UAH students traditionally. Students at each school were administered the same material and take-home exams and each student was required to submit a research paper.

Overall ANOVA exam performances indicated the NTU students, as a group, performed the best and had the least inter-student variation (smallest standard deviation). The younger GaTech students performed significantly lower. Sounder concluded that the NTU students' superior performance was attributable to their age and experience advantages, which helped them overcome possible disadvantages of being separated from the instructor. Sounder reported strong social and motivational factors were present. However, the NTU students did not record better scores on all exam questions.

Sounder (1993) concluded that distance learners perform as well as or better than their traditional classroom counterparts in a master's level management of technology program. The study's evidence was in line with previous research findings that distance learners are not disadvantaged when compared to traditional learners (Delbeq & Scates, 1989; Moore & Thompson, 1990; U.S. Congress, 1989). Moreover, Sounder's distance learners gained more than their traditional counterparts. They broadened their network of professional contacts, improved their coordination skills with others over distances, and obtained other skills beyond those offered with traditional learning.

However, Sounder (1993) reported that his results as in other studies (Bajtelsmit, 1990; Moore & Thompson, 1990; U.S. Congress, 1989) indicated that successful distance learners demonstrated a high degree of commitment and maturity. They were highly motivated compared to conventionally taught students.

Because distance education is a complex socio-psychological innovation, Sounder (1993) suggested that more empirical evaluation was needed to investigate the profile of a successful distance learner and that successful distance learning experiences need to be compiled as a basis for designing optimal distance learning programs (Sounder, 1993). Moore et al. (1990) concurred that further study regarding which teaching techniques generate the best results in distance education is needed.

Learner Perceptions and Attitudes

Researchers have investigated learner attitudes from several perspectives. Some looked at quantitative and qualitative learner satisfaction while others tried to evaluate what students thought of the new teaching technologies as well as the teaching methodology (Moore et al, 1990).

K-12 learner perceptions and attitudes. Two researchers reported mixed results in their attempts to quantify student perceptions. Nelson (1985) surveyed students using the Iowa TWIT system and found 97% had no problems with the televised classes; 67% believed they had accepted more responsibility for their behavior in the TWIT classes; 97% percent said they would take another videoteleconferenced class; and 94% thought they did as well as or better in the TWIT classes. On the other hand, Barker's (1987) survey of TI-IN satellite network students produced significantly different opinions. Most students (65%) thought the video satellite course was more difficult than their regular classes. Nearly 70% said they would rather take a traditionally taught course. Students complained the audio was difficult to hear, it was hard to reach the teacher, they were given too much work, and the teacher was

inadequately prepared and trained. The students did like the increased variety of course offerings but recommended audio quality be improved, larger monitors be used, and the receiving equipment be properly maintained (Barker, (1987).

Adult learner perceptions and attitudes. Most studies indicated adult attitudes regarding distance education technology were positive (Christopher, 1982; Kruh, 1983; Sounder, 1993). In a study involving six universities, Kruh (1983) found student satisfaction with teleconferencing courses equal to student satisfaction with resident, face-to-face classes.

Three separate studies (Haaland & Newby, 1984; Partin & Atkins, 1984; Shaeffer & Roel, 1985) generally concluded that the student's rating of a telecourse hinged on the instructors teaching style and abilities and not the technology used to deliver the material. Partin and Atkins (1984) reported students were generally receptive to technological delivery but the students also indicated the value of having a facilitator at the site along with properly functioning equipment.

Interactivity

Over the years, educators have stressed the importance of instructor/learner interaction. This interactivity, which has been described as two-way contact between participants, can vary from written comments on student work to face-to-face discussions. Ober, Bentley, and Miller (1971) described the teaching-learning situation as an interaction among the teacher, student, and content adding that teachers are responsible for the encouragement, facilitation, and even the genesis of thinking of their assigned students. The development of thinking requires a purposeful interaction of teacher with the students among other things. According to Stephenson (1992-1993), learning is a social event for some students. In a traditional classroom environment, the instructor is responsible for providing most of the social functions or interactivity.

The importance of educational interaction has been shown in a number of ways. First, interaction in the form of dialogue is a common means of educational communication. Second, some researchers have found that student performance increases with greater interactivity. Third, students work harder and score higher if they anticipate interaction (Ritchie & Newby, 1989). As mentioned earlier, studies have shown distance learners perform as well as or better than their traditionally taught counterparts (Moore et al., 1990).

Interaction in K-12 distance education has been shown to be just as important as it is in traditional face-to-face education. Threlkeld (1990) tabulated results of a 1989-90 survey of superintendents in 415 California school districts designed to evaluate the relative importance of learning attributes in satellite-delivered high school education. Although the return-rate was only 58%, students reported that an ability to communicate with the instructor during the class along with the need for on-site library materials were their two top concerns. Threlkeld (1990) stressed the necessity for interaction between teachers and students in his analysis.

While some research has shown that instructor interaction with students positively influences achievement, other studies have shown student needs for interaction are dependent on individual maturity and motivation (Barnard, 1992; Stephenson, 1992-1993). Sounder (1993) attributed superior student performance by the distance learners in his videoteleconferencing experiment to their older ages and greater work experience. His findings, as in other studies (Bajtelsmit, 1990; Moore & Thompson, 1990; U.S. Congress, 1989), indicated that successful distance learners demonstrate a high degree of commitment and maturity. In a survey of California State University students taking videoteleconferencing courses via one-way video (with two-way audio), adult students indicated live interaction was not as important to them as high school students did using the same system. Less experienced students invariably expressed a greater need for interactivity (Barnard, 1992).

In 1989, Ritchie and Newby conducted a study to compare the factor of interaction afforded by an educational videoteleconferencing system with the interaction possible in a traditional classroom. They randomly divided 26 subjects (undergraduate college students) into three different educational settings: (a) a traditional classroom in the presence of an instructor, (b) a TV broadcast studio classroom in the presence of an instructor (live studio), and (c) a studio classroom with television monitors instead of an instructor (distance). Students received a 13-minute lecture on nominative absolute clauses. The content had been previously field tested and shown to be novel for the population selected. The distance group had significantly higher achievement scores on the posttest than the other groups even though the students in the traditional classroom interacted twice as often as the combined total of both the studio and distance groups.

Three years later, Stephenson (1992) explored the impact of instructor/student interaction with students working in a computer-based training (CBT) environment. He divided 41 business-statistics subjects into two groups to perform statistical calculations. Group one (n=22) received essentially no instructor-initiated interactions while the second group (n=19) was exposed to multiple instructor-initiated interactions. Both groups were allowed to ask the instructor questions when they did not understand the computer tutorial. All subjects in each group worked in pairs.

In a previous study with students working independently but with access to an instructor, Stephenson (1991) found instructor interaction positively affected student achievement. However, results from his 1992 study with students working in pairs indicated instructor interaction had no effect on achievement. He attributed this finding to the synergy created by the interaction between the students paired together. "Whatever it is about the effect of social facilitation on learning is served quite well by the partner in a study team and, in fact, may be served better than by an instructor" (Stephenson, 1992-1993, p. 33).

In a U.S. Army study, Lehman and Kinney (1992) found that student soldiers participating in a one-way video (with two-way audio) learning environment significantly outperformed their counterparts who received the same training via a two-way video (with two-way audio) system. Posttest results indicated that the significant differences between student scores in different delivery systems were due to differences in training methods and not differences in the way the distance learning sites were configured. However, the 13-month study did not observe or address the potential impact of student/instructor interactivity in either delivery system.

Monson (1978) identified four interactive design characteristics of successful teleconferencing. First, the course must humanize the learning process by focusing on the distant learner to generate group rapport. Second, student participation must be emphasized to generate spontaneous interaction between participants. Third, instructors must use a presentation style students understand and remember. Fourth, continuous feedback is required to complete an effective communication loop.

Moore et al. (1990) suggested more research was needed on how teachers can facilitate greater interaction. Kruh and Murphy (1990) reported that distance education courses were usually a passive experience for the learner. Distance educators frequently use a lecture style, which emphasizes memorization and recall rather than cognitive skills. At the University of Oklahoma, two-thirds of the television-delivered courses used only instructor-centered strategies. However, more than two-thirds of traditional classes were also reported to have used teacher-centered techniques (Dillon, Hengst, & Zoller, 1989). Moore et al. (1990) said teachers need to avoid using the lecture style for live teleconferences. Lectures should be recorded because they are not interactive by nature. They concluded live that two-way EVC lends itself to greater student/teacher interactivity.

Socialization. Looking at an aspect of interaction beyond its instructional value, Hawkins (1991) posed the question, "What are the consequences of these new circumstances for student learning and for the social aspects of schooling experiences?" (p. 174). Hawkins recommended longitudinal research was needed to help determine what impact distance learning technologies have on student perspectives on the issues they study and on the quality of their relationships with fellow students, arguing the ultimate goal was to determine which designs are most effective for cognitive and social development in distance learning.

Summary

This literature review discussed videoteleconferencing technology and its applications in business and the military with an in-depth look at distance education. Replacing analog, full-motion video with digitally compressed-motion video has significantly reduced videoteleconferencing transmission expenses despite continual codec compatibility problems. Phone lines, cable television, microwave systems, satellites, and fiber optics have all been effectively used to transmit audio and video images. All three forms of teleconferencing--video, audio, and computer--have been used to deliver distance learning instruction in a wide variety of settings and learning situations.

Most studies revealed distance learning students who receive technology delivered instruction perform as well as or better than their traditionally-taught peers (Moore et al., 1990). Student perceptions about videoteleconferencing have generally been positive (Partin & Atkins, 1984). Some research has shown that instructor interaction with students positively influences achievement while other studies have shown student needs for interaction are dependent on individual maturity and motivation (Barnard, 1992; Stephenson, 1992-1993).

While this investigator found research comparing EVC effectiveness with traditional classroom education, he found only one study in which the two-most interactive types of full-motion videoteleconferencing systems were compared (Lehman & Kinney, 1992). However, the

13-month study did not observe or address the potential impact of student/instructor interactivity on cognition in either delivery system.

Chapter 3

Methodology

This chapter discusses the research methodology employed to compare learning effectiveness in two educational videoteleconferencing systems (one-way video with two-way audio and two-way video with two-way audio videoteleconferencing).

Statement of the Problem

Specifically, this project was designed to answer the following question: *Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing (EVC)?*

Research sub-questions. The following research sub-questions were developed to examine and evaluate student cognition, student/instructor interaction, and attitudes about the technology in EVC:

1. Are there any differences in student cognition between one-way video and two-way video EVC?

2. Are there any differences in student/instructor interactivity between one-way video and two-way video EVC?

3. What is the relationship between student/instructor interactivity and cognition in one-way video and two-way video EVC?

4. What is the relationship between gender and cognition in one-way video and two-way video EVC?

5. What is the relationship between EVC experience and cognition in one-way video and two-way video EVC?

6. What is the relationship between attitudes about EVC technology and cognition in one-way video and two-way video EVC?

Hypothesis. Based on the literature, this study hypothesized that students in both EVC systems would perform similarly. College-level student cognition has not been shown to differ significantly with the increased ability to interact with the instructor in a distance learning environment (Ritchie & Newby, 1989; Stone, 1988). Ritchie and Newby (1989) found that undergraduate students first experiencing interactive television instruction felt less involved in the class and did not ask questions of the instructor even when two-way audio was available. One directional hypothesis, related to Research Sub-question 1, was developed for this study:

H_1) There is no difference in college student cognition when comparing two-way video with two-way audio EVC and one-way video with two-way audio EVC.

An experiment was designed to compare the effectiveness of the two most interactive types of EVC systems by evaluating student cognitive performance, the amount of student/instructor interaction, and consumer satisfaction in the two EVC environments. According to Barker, Frisbie, and Patrick (1989), full-motion, two-way video with two-way audio links followed by one-way video with two-way audio links provide the greatest opportunity for student/instructor interaction.

Data Collection

Subjects. A form of convenience sampling was employed to obtain subjects, who were undergraduate university students enrolled in a 400-level (senior) mass communication course entitled "Cable TV/Emerging Telecommunications" at Arizona State University in Tempe. Participation was voluntary. The Human Subjects Institutional Review Board (IRB) at Arizona State University granted approval to conduct this experimental research project with human subjects on 16 February 1995 (see Appendix D). All student participants signed a consent letter authorizing themselves to be videotaped during the experiment (see Appendix E for a sample consent letter).

According to Osgood, Suci, and Tannenbaum (1957), three advantages to using college students when measuring communication constructs such as interaction are:

> . . . such subjects are probably more representative of the sorts of populations that will be used in most applications of the final instruments; having a higher average intelligence they probably yield a clearer picture of the most finely differentiated semantic space. Finally, we have available subsidiary factor data from the general population to serve as a check on the college population. (p. 32)

A recruitment handout requesting volunteers for this research was given to approximately 34 students in their normal class time five days before the experiment (see Appendix F). Students were told when and where to show up if they desired to participate in an experiment about educational videoteleconferencing delivery systems.

Of the 34 students, 15 volunteered to participate. However, one dropped out prior to the experimental procedure, leaving 14. The majority of these 14 subjects were seniors (10) while 2 were juniors and 2 were graduate students. The sample was evenly divided by gender with 7 females and 7 males. As expected in a senior-level class, the median age of the 14 subjects was 22.5 years, ranging from 20 to 39. (Only one student was older than 26; a 39-year-old male graduate student.) All subjects identified themselves as Caucasian except one who identified herself as Hispanic.

Treatment. The College of Extended Education at Arizona State University supplied two virtually identical videteleconferencing classrooms already configured for the daily transmission of one-way video with two-way audio via the Instructional Television Fixed Service (ITFS) as a part of the university's Interactive Instructional Television Program. In this study, the classrooms were used to send and receive both one-way and two-way EVC. The instructor's videoconferencing classroom had 3 cameras, 22 desktop microphones, and 4 television monitors (1 13-inch and 3-27 inch) (see Appendix C). The receiving

videoconferencing classroom, where the subjects' received the instruction, was similarly configured: 3 cameras, 20 desktop microphones, and 3 27-inch television monitors (see Appendix C).

Instruction was delivered by the students' actual instructor, Tom Crosby, to a total of 14 subjects divided into two separate but virtually identical presentations. Subjects were randomely assigned to one of two conditions: Group A had instruction delivered by two-way video (with two-way audio) while Group B had instruction delivered by one-way video (with two-way audio).

Because cognition could be related to gender, subjects were assigned so that each group would be proportionally equal by gender: Group A had 4 females and 4 males and Group B had 3 females and 3 males. The median age of Group A was 23.0 years, while Group B's median age was 22.5.

Subjects were proportionally divided by class standing with one junior and graduate student in each group. The self-reported GPAs (grade point average) of each group were similar: 3.18 for Group A and 3.25 for Group B. In a further effort to control for intervening variables, a comparison was made of the two groups' mean scores on the first examination given in their regular class five days prior to the experiment. Group A had a mean score of 86.5%; Group B's mean score was 85.2%.

Most of the subjects had no experience with videoteleconferencing; however, 2 subjects in Group A reported they had participated in at least one videoteleconferencing class or conference but did not consider themselves experts with the technology. In Group B, 1 student indicated he had extensive work experience and 1 student had participated in at least one videoteleconference.

To reduce experimenter bias, students were not told there would be any differences in the delivery of instruction to each group (Wimmer & Dominick, 1991). The settings for the instructor and students were configured as follows:

1) Instructor Classroom/Studio (see Appendix C): A 13-inch television monitor on a table in front of the instructor enabled him to view Group A students during the two-way video with two-way audio videoteleconference. Two video cameras at the back of the classroom spaced 10 feet apart provided video of the instructor. A third camera mounted on the ceiling above the instructor provided close-ups of the instructor's graphics--a content outline with basic diagrams. The classroom was similar to the studio/classroom where the subjects received the videoteleconferenced instruction.

2) Group A Classroom/Studio: Subjects received two-way video with two-way audio EVC (see Appendix C). The students could see, hear, and communicate live with the distant instructor electronically via a combination of desktop microphones and television monitors. A ceiling-mounted video camera in the front of the classroom provided the instructor (located in the other videoconferencing classroom) full-motion visuals of the students. The classroom had 3 long rectangular tables with seats for 7 students each. Overall seating capacity for the classroom was 26. Each subject had direct access to a desktop microphone mounted on the table in front of the subject. Three wall-mounted 27" television monitors showed students visuals of the instructor and his graphics. The ceiling camera over the instructor provided visuals of the students for the distant instructor.

3) Group B Classroom/Studio: Subjects received one-way video with two-way audio EVC (see Appendix C). The students could see, hear, and communicate live with the distant instructor electronically via a combination of desktop microphones and television monitors. In this setting, the instructor could hear the students but could not see them. The classroom, which was the same one used for Group A, was configured exactly as it had been for Group A's

treatment with one exception: although the ceiling-mounted camera was operational (to record the students' activities), student images were not transmitted to the instructor.

To preserve the "instructor's" role (Ritchie & Newby, 1989), the researcher re-introduced each group to the study at the beginning of each treatment and instructed subjects on how to use the push-button microphones needed for interaction with the instructor (see Appendix G for a copy of the oral instructions).

The instructional material was presented twice. The first presentation lasted 12 minutes and the second lasted 11 minutes. The lectures' main topic was ITFS and MMDS (Multiple Multi-point Distribution Service) technology and applications. EVC equipment found at a typical distance learning classroom was also explained. A dry-run was conducted two weeks before the experiment to familiarize the instructor with the operation of EVC equipment and to insure the equipment could be configured as needed for the experiment. Instructor-prepared graphics outlining the content with basic diagrams were displayed on the students' TV monitors during the presentation. Whenever the graphics were shown, the instructor was superimposed into a small square in a corner of the screen to enable the students to see both the instructor and the graphics simultaneously. In an attempt to spark student/instructor interaction during the experiment, the instructor specifically asked both groups several times if they had any questions.

Immediately after each lecture/presentation on ITFS and MMDS technology, each group was moved to a regular classroom and administered a posttest and questionnaire by a proctor. The experiment, including the subject pre-briefing, 2 instructional phases, the administration of 2 posttests with questionnaires, and a post-experiment debriefing took 75 minutes to complete (see Appendix H).

<u>Instruments</u>. Four instruments were used to collect data: a cognitive posttest, a student questionnaire (see Appendix A), a student/instructor interaction observation form based on a

form (see Appendix I) developed by Ober, Bentley, and Miller (1971), and by handwritten notes taken by the researcher in a post-experiment interview with the instructor (see Appendix B). The cognitive instrument and student questionnaire containing demographic and attitudinal items were combined into one instrument (see Appendix A). The first 10 items on the cognitive portion of that instrument were a combination of fill-in-the-blank, multiple choice, and true/false questions designed to measure cognition of the lecture. Items 11 through 16 requested demographic information. Items 17 through 22 surveyed perceptions and attitudes about the technology used to deliver the instruction, including a rating of the importance of student/teacher interactivity as well as comparisons of EVC and traditional classroom instruction.

Attitudinal responses in items 17 and 20 were measured via the semantic differential technique conceived by Osgood et al. (1957) and Likert scales. A semantic differential is a rating scale normally consisting of seven spaces between two bipolar adjectives; for example, "good ___: ___: ___: ___: ___: ___: ___ bad" (Wimmer & Dominick, 1991, p. 460). These scales have been effectively used to measure perceptions and attitudes about objects, persons, and concepts. As recommended by Wimmer and Dominick (1991), a unique set of anchoring adjectives were developed for two questions on the attitudinal portion of the instrument. The positions of positive and negative terms were alternated within the scales to maintain attitude consistency (Wimmer & Dominick, 1991). Modified semantic scales (five-point scales as opposed to traditional seven-point semantic differential scales) were used in this research.

To measure the importance of student/instructor interactivity (item 18), a set of Likert scales was also employed as they are considered the most effective for measuring attitudes and are the most commonly used scales in mass communication research (Wimmer & Dominick, 1991). Respondents were asked to determine the importance of student/teacher

interactivity--the ability for students and instructors to spontaneously communicate during class. Student choices included: very important, important, neutral, unimportant, and very unimportant.

Items 21 and 22, exploring student satisfaction with instruction during the treatment, were open-ended.

The cognitive items (questions 1 through 10), designed jointly by the researcher and the instructor, were evaluated for accuracy and relevancy by Elizabeth Craft, the Director of Distance Learning Technology at Arizona State University, and by Dr. John Craft--an expert on telecommunication technology in the Walter Cronkite School of Journalism and Telecommunication at Arizona State University.

To measure the amount of student/instructor interaction, each group was recorded on videotape during the instruction. To identify the amount and types of interactions, a modified form of the Ober, Bentley, and Miller (1971) Equivalent Talk Categories model employed by Ritchie and Newby (1989) was used. This systematic observation system, which served as an organized frame of reference for monitoring and describing actual classroom interaction, divides interactions into 4 categories: (1) restricted thinking questions classified as memory or knowledge; (2) expanded thinking questions classified as interpretation, analysis, or synthesis; (3) restricted thinking responses classified analogous to the questions' categories; and (4) reactions to extend the level of participation classified as extending the level of thinking.

Immediately after the experiment was concluded, the researcher conducted an interview with the instructor to determine which delivery method he preferred and why. The researcher took notes during this interview.

No pretest was administered in an attempt to eliminate the possibility of subject sensitization to the posttest.

Data Analysis

Mean cognitive scores from each group were compared in an attempt to determine which distance delivery system generated greater cognition. The mean cognition score of each group was determined by averaging individual results from the 10 cognition questions on the instrument. Each question was worth 10 points. Responses to the semantic differential items were weighted from 1 to 5 after realigning items in the same direction. A t-test was then performed to compare the semantic differential responses (items 17 and 20). Responses to the Likert scales (item 18) and the forced choice question (item 19) were totaled and converted to percentages for comparison. The open-ended responses (items 21 and 22) were content analyzed for trends and relevant comments were presented verbatim. Demographic data (items 11-16) were totaled and converted to percentages. Demographic and attitudinal data from items 17 through 22 were also compared with individual and group performance on the cognitive portion of the instrument to identify possible trends.

The quantity and type of student/instructor interactions of each group were monitored to determine what impact interaction has on cognition in different distance learning environments. Cognition means were compared with group interaction data to determine if there is a relationship between interactivity and cognition.

Summary

This chapter discussed the characteristics of the sample population, the settings, and the experimental methods utilized to determine which EVC system was more effective.

The sample population for this pilot study consisted of 14 college students divided into two proportionally equal groups. Each group received a live presentation of the same lecture via one of two EVC systems (one-way or two-way video).

Arizona State University supplied two EVC classrooms for the research. The rooms were modified to transmit and receive both one-way video and two-way video EVC.

Four instruments were developed to measure the effectiveness of one-way video EVC and two-way EVC: (1) cognition was measured on a 10-item posttest on the lecture presented for each group; (2) student/instructor interactivity was monitored and noted on a modified form of the Ober, Bentley, and Miller (1971) Equivalent Talk Categories Model; (3) student satisfaction was evaluated on a questionnaire; (4) and a post-experiment interview was conducted to ascertain which EVC system the instructor preferred and why. Demographic data was also solicited to determine whether gender, prior videoteleconferencing experience, or attitude affected cognition in an EVC environment.

Chapter 4

Findings

Results from the study are presented by research question in this chapter.

Research Sub-question 1

Are there any differences in student cognition between one-way video and two-way video EVC?

There were no differences in student cognition between the two EVC systems compared (one-way video and two-way video EVC).

The mean cognitive score for Group A was 72.5% while the mean score for Group B was 73.3% (t=.133). Scores on the cognitive portion of the instrument (items 1-10) for Group A ranged from 60- to 80% with a standard deviation of 6.6 while Group B scores ranged from 60-90% with a standard deviation of 13.7.

Hypothesis. H_1) *There is no difference in college student cognition when comparing two-way video with two-way audio EVC and one-way video with two-way audio EVC.*

H_1 was supported. A t-test revealed there was no significant difference in college student cognition between two-way video and one-way video EVC (t=.133).

Research Sub-question 2

Are there any differences in student/instructor interactivity between one-way video and two-way video EVC?

There were no differences in student/instructor interaction when one-way video and two-way video EVC were compared.

All communication during the experiment was one-way. Subjects did not interact with the instructor other than to listen to the lecture. Even when the instructor directly asked, no questions or responses materialized from any subject in either group. All 8 subjects in Group

A listened to the instructor and did not take notes. In Group B, all subjects also listened; however, 2 of the 6 subjects took notes on the material presented.

Despite the absence of student/instructor interaction, most students (9 out of 14) reported that student/instructor interaction was "very important" in an educational videoteleconference. Another 3 subjects indicated this was "important" while 2 were neutral. Furthermore, almost half of Group A (3 of 8 subjects) were satisfied with their ability to interact during the experiment while all 6 subjects in Group B were satisfied. When asked if videoteleconferencing inhibits interaction with the instructor, the majority of Group A students (5 out of 8) said the technology did inhibit communication while the 6 subjects in Group B were equally divided.

Group A students who were not satisfied with their ability to interact (communicate) with the instructor during the experiment explained that the process was impersonal. One student wrote, "Distant learning makes you feel distant from the instructor," while another added it was "intimidating to talk by microphone". Yet another reported, "It felt uncomfortable trying to communicate . . . . It did not feel personable. This technology takes away from the student/teacher interaction." These same subjects also wrote that videoteleconferencing inhibited them from communicating with the instructor during the presentation. Spontaneity between the students and the instructor was lost. One male student explained the videoteleconference was boring because the "instructor changed". A female wrote, "It seems difficult to interrupt the instructor during this type of lecture. It's easier to communicate with him (the professor) when he's standing in front of me." Another male subject wrote he was inhibited because he knew it was an experiment, and then added, "Did I just mess up your project?"

Those Group A students who were satisfied with their ability to interact with instructor indicated that being cognizant of the ability to interact was enough for them. One female said she

felt comfortable with the access to the instructor because the subject matter was clearly presented and she rarely interacted with professors in straight lecture classes anyway.

All 6 subjects in Group B were satisfied with their ability to interact with the professor. Half of group was satisfied with their ability to interact because they knew they could easily ask a question if the need arose. While all of these subjects were satisfied with their ability to interact, half of the subjects also felt inhibited about communicating with the instructor. One male wrote, "I would have rather communicated with him (the instructor) via the telephone than by pushing a white microphone button." Another male wrote that videoteleconferencing "removes the informal communication/interaction. There is no banter." A female student cited unfamiliarity as an inhibiting factor and explained, "It's easier to pay attention to a live person than a talking head on screen. It's too boring to absorb the information." Intimidation was also mentioned by one female as an inhibiting interaction factor in Group B.

The instructor preferred the two-way video EVC system. With the two-way video EVC he said he could, "see if the students understood the lecture. The ability to see the students humanized the process." With one-way video EVC, the instructor said, "The students don't exist." He added that if some students were present in the same distance learning classroom as the instructor, "I could play to the students and forget the cameras."

Research Sub-question 3

What is the relationship between student/instructor interactivity and cognition in one-way video and two-way video EVC?

The experiment did not provide any data to answer this question.

No interactions were recorded because neither group orally communicated with, questioned, or responded to the instructor during the videoteleconference. Due to the absence of

student/instructor interaction in this experiment, no relationships could be determined between the amount and type of interactions and student cognition.

Research Sub-question 4

What is the relationship between gender and cognition in one-way video and two-way video EVC?

There is no relationship between gender and cognition.

A t-test revealed there was no significant difference between the combined mean scores of all males and all females from both groups (t=0.50). The combined mean for all males in both groups was 77% while the overall mean for all females was 68.57%. The cognitive mean score for males was higher in both groups but not significantly. The cognitive mean score for Group A males was 75% while the females had a score of 70%. In Group B, the average male score was 80% and the average female score was 66.7%. No females in either group had any prior experience with videoteleconferencing while more than half of the males (4 out of 7) had participated in at least one videoteleconference class or conference.

When given a choice, the majority of both male and female subjects (8 out of 14) preferred traditional classroom education over videoteleconferencing. Half of all the males and females said they preferred traditional classroom education while 2 males and 2 females said they had no preference and only 1 male and 1 female preferred EVC. In Group A, 5 out of 8 students chose videoteleconferencing and the other 3 said it did not matter. While no one in Group A preferred videoteleconferencing, 2 subjects in Group B (a male and a female) did. However, 3 subjects in Group B preferred the traditional classroom environment and 1 said it did not matter.

Research Sub-question 5

What is the relationship between EVC experience and cognition in one-way video and two-way video EVC?

There is a significant relationship between EVC experience and cognition in one-way video and two-way video EVC.

The 4 subjects with prior EVC experience scored significantly higher than the 10 subjects with none ($t=2.87$, $p<.02$). Students with at least one videoteleconferencing experience or more had higher mean scores--82.5% compared to 69% for inexperienced (first-time) students. Each group had an equal number of students (2 each, all male) who had participated in at least one videoteleconference. Despite scoring higher than their inexperienced counterparts, all 4 experienced subjects indicated they felt inhibited about communicating with the instructor.

Research Sub-question 6

What is the relationship between attitudes about EVC technology and cognition in one-way video and two-way video EVC?

There is no relationship between attitudes and cognition in one-way video and two-way video EVC.

Attitudinal opinions about EVC technology were not significantly related to student cognition in either group or overall. Only 1 individual, a Group A male, was extremely negative about EVC and he scored 70% correct, just under the overall mean of 72.9%.

However, both groups were more positive toward traditional classroom education than EVC. On item 17, both groups rated videoteleconferencing more positively than negatively with a combined semantic differential mean of 3.57 on a 5-point scale. Group B was slightly more positive about videoteleconferencing than Group A ($t=1.77$, $p<.10$) but not significantly. The semantic differential mean for Group A was 3.4 compared to Group B's score of 3.8.

Despite each group's positive inclination about videoteleconferencing technology, both were similarly positive about traditional classroom education. Group A's semantic differential mean score was 3.9 and Group B's was 4.03, a combined average of 3.96 ($t=.49$). However,

Group A was significantly more positive about traditional classroom education than they were about EVC ($t=2.63$, $p<.02$). In Group B, there was no significant difference between their attitudes about EVC and traditional classroom education ($t=.83$).

The majority of subjects (both groups) indicated videoteleconferencing was "valuable" (9 out of 14) and "interesting" (10 out of 14) while 10 out of 14 also found traditional face-to-face classroom education to be "valuable" when compared to EVC and 8 out of 14 said the traditional method was "interesting" when compared to EVC. Both groups rated videoteleconferencing similarly in these two categories (valuable and interesting). Only 3 subjects in Group A and 2 in Group B indicated videoteleconferencing was easy, but subjects also rated traditional face-to-face classroom education similarly. Three subjects in each group indicated that traditional face-to-face classroom was easy.

<u>Overall Research Question</u>

Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing (EVC)?

There is no significant difference in effectiveness between two-way video and one-way video EVC.

Neither videoteleconferencing system (the two-way video with two-way audio or the one-way video with two-way audio) had a significantly different effect on group cognition ($t=.133$). The mean score for Group A was 72.5% correct while the mean score for Group B was 73.3% correct. The potential impact of student/instructor interactivity on EVC effectiveness could not be evaluated in this experiment because there was no oral interaction in either group. Subject satisfaction with or attitude about the EVC system used to deliver the instruction did not effect cognitive performance on the instrument. While both groups were positive about EVC, Group B was more positive ($t=1.77$, $p<.10$) but not significantly.

Both groups were relatively equal in comparison. The mean grade point (GPA) average for both groups of subjects while attending Arizona State University indicates neither group had an academic advantage over the other. Group A had a self-proclaimed mean GPA of 3.18 out of a possible 4.0 while Group B had a self-proclaimed mean GPA of 3.25. The self-stated GPAs mirrored actual student performance on their first class examination administered 5 days prior to the experiment by their instructor (the same instructor in the experiment). In comparing the groups' cognitive performance on their first class examination, Group A had a mean score of 86.5% while Group B's mean score on their class examination was 85.3%.

The proportion of graduate students, seniors, and juniors in each group was similar. Group A was composed of 1 graduate student, 6 seniors, and 1 junior while Group B had 1 graduate student, 4 seniors, and 1 junior. The average age for Group A was 23 years, and Group B had an average age of 25 years. Each group had an equal number of male and female subjects with similar videoteleconferencing backgrounds. None of the females in either group reported having any experience with videoteleconferencing.

Summary

Results from the data support H_1 and indicate there were no differences in student cognition between the two EVC systems compared (one-way video and two-way video EVC). Both groups were virtually equal and performed similarly on the cognitive portion of the instrument ($t=.133$).

There were no differences in student/instructor interaction in one-way video and two-way video EVC. All communication during both phases of the experiment was one-way. Subjects did not interact with the instructor other than to listen to the lecture.

There is no relationship between gender and cognition in the two EVC environments and there is no relationship between attitudes and cognition in one-way video and two-way video EVC. However, both groups were positive about EVC and traditional classroom education.

Subjects in Group B (one-way video with two-way audio) were more positive about EVC than Group A subjects but not significantly ($t=1.77$, $p<.10$). Group A was significantly more positive about traditional classroom education than they were about EVC ($t=2.63$, $p<.02$).

Chapter 5

Discussion

Conclusions about the findings comparing the effectiveness of two interactive educational videoteleconferencing systems are presented in this chapter along with implications and recommendations for further study.

Conclusions

Is live two-way video with two-way audio more effective than live one-way video with two-way audio educational videoteleconferencing (EVC)?

As evidenced in the findings of this research, the data collected failed to indicate any significant differences in cognition between college students who received the same instruction via two different interactive EVC delivery systems.

Research has consistently shown that distance learning students perform as well as or better than their traditionally taught counterparts (Moore et al., 1990; Threlkeld, 1990). While educators have stressed the importance of interaction in distance learning (Ober, Bentley, & Miller, 1971), this investigator found relatively little research that directly compared the effectiveness of the two most interactive types of educational videoteleconferencing systems. Despite the fact that two-way video with two-way audio videoteleconferencing has been labeled the most interactive (Barker, Frisbie, & Patrick, 1989), it has not been shown to be the most effective delivery system for distance education.

The impact of student/instructor interaction on cognition and learning effectiveness was not examined due to the absence of oral interaction from the students. Without student interaction, one aspect of effectiveness was not able to be addressed. The lack of student/instructor interaction could be attributed to a number of factors: the short duration of the presentations (11 to 12 minutes), the novelty of the environment for the students,

instructor inexperience with teaching in an EVC setting, a well planned and clearly presented lecture, and artificiality.

The material for the instruction was clearly presented in relatively short blocks of time (when compared to the length of normal classroom lectures), well organized, and enhanced by effective graphics. Subjects could have become more comfortable about asking questions if the presentation had lasted longer.

Media specialists responsible for the operation of Arizona State University's distance learning studios explained that new, inexperienced videoteleconferencing students don't normally interact with their professors until mid-semester, even when the professor stresses the importance of communication and strongly elicits participation. Ritchie and Newby (1989) found that undergraduate students first experiencing interactive television instruction felt less involved in the class and did not ask questions of the instructor even when two-way audio was available. Despite the majority of subjects (10 out of 14) being unfamiliar with the experimental setting, all of the subjects were very familiar with the instructor and his normal teaching style. Some noted a change in his teaching style which could be attributed to a change in the teaching venue.

The technology of the delivery system and the artificiality of the experiment could have affected the instructor's performance. Open-ended comments from the instrument indicate the instructor switched from a very personable and interactive teaching approach to a more formal, lecture style that was not conducive to interaction even though he asked for student input. The instructor acknowledged the change in his teaching style and attributed it to the medium. While the instructor had experience operating videoteleconferencing equipment, this was his first time teaching in front of video cameras. As stated in the limitations, he may have been uncomfortable teaching in a room without students present.

The majority of subjects indicated that student/instructor interaction was very important in the learning process despite the lack of student/instructor interaction. However, this finding did not support the literature. In a survey of California State University students taking videoteleconferencing courses via one-way video with two-way audio, adult students indicated live interaction was not as important to them as did the high school students who had used the same system; i.e., younger students invariably expressed a greater need for interactivity (Barnard, 1992). While some research has shown that instructor interaction with students positively influences achievement, other studies have shown student needs for interaction are dependent on individual maturity and motivation (Stephenson, 1992-1993; Barnard, 1992). Sounder (1993) attributed superior student performance by the distance learners in his videoteleconferencing experiment to their older ages and greater work experience. His findings, as in other studies (Bajtelsmit, 1990; Moore & Thompson, 1990; U.S. Congress, 1989), indicated that successful distance learners demonstrate a high degree of commitment and maturity.

From the subjects' point of view, both EVC receiving sites were essentially identical. Differences were transparent to the subjects. However, Group A was aware the instructor could see them and Group B knew the instructor could not see them. Each group saw and heard the professor in the exact same setting. The instructor was the only participant who actually saw any differences between the two delivery systems.

Subject perceptions about videoteleconferencing were positive in both groups, however, the majority of subjects had a greater affinity for traditional face-to-face classroom education. Although cognitive performance for both groups was similar, Group A subjects were significantly more positive about traditional classroom education than they were about two-way video EVC ($t=2.63$, $p<.02$). Conversely, Group B was slightly more positive about one-way video EVC than Group A had been about two-way video EVC but not significantly ($t=1.77$,

p<.10). However, the small size of both groups (8 and 6 subjects) prevents generalizing the finding that Group A viewed traditional classroom education more favorably than two-way video EVC.

Partin and Atkins (1984) reported that students are generally receptive to technological delivery. They and others (Haaland & Newby, 1984; Shaeffer & Roel, 1985) found that the students' rating of a telecourse hinged on the instructors' teaching style and abilities and not the technology used to deliver the material. Subjects in the current experiment may have been reacting more to the lecture/presentation than the technology of the delivery medium.

Implications

Results imply that, since students performed similarly in both settings, training and educational institutions can reduce expense by utilizing the less expensive one-way video with two-way videoteleconferencing instead of two-way video with two-way audio videoteleconferencing. However, even though there was no significant difference between the two groups' cognitive performances, two-way video EVC offers the added benefit of visual feedback for the instructor. The instructor preferred the two-way video EVC over the one-way because he could see the students. Although neither group of subjects orally responded to the instructor, the instructor could still see whether the students were attentive and how they were reacting to the material presented during the two-way video.

It appears that greater student familiarity and experience with videoteleconferencing could significantly enhance cognition but may not reduce inhibitions about verbal interaction with the instructor. Although subjects with prior videoteleconferencing experience performed significantly better than their inexperienced counterparts (t=2.87, p<.02), this could be attributed to the content of the lecture, ie., the experienced subjects may have already been familiar with ITFS and MMDS technology.

The data produced f rom this research supports H_1, that college students would perform similarly in both EVC environments regardless of the potential for greater interaction in the reportedly more interactive two-way video with two-way audio videoteleconferencing system. However, the small size of the sample population of this pilot study prevents generalizing the findings to the overall population of college students.

Recommendations

For implementation. Researchers wishing to obtain a sufficient number of participants should notify potential subjects at the start of the students' normal class time, on the same day, and at the same time they wish to conduct the experiment. Students will already be present and more inclined to participate. In this study, the subjects were notified two days prior to the experiment that volunteers were needed for research on videoteleconferencing. This advance notification along with ASU Human Institutional Review Board requirements that the potential subjects be told their participation was strictly volunteer and that anyone not wishing to participate could do so without fear of retribution contributed to the low participation rate. The lack of any incentive to attend, i.e., extra credit, could also have inhibited the size of the sample.

Student/instructor interaction could be better facilitated by having some students in the same classroom as the instructor during the instructional phases. The instructor's teaching style may have been affected by the absence of students in the same studio/classroom. In most distance learning classrooms at ASU, there are students in the same room as the distant instructor. With students in the instructor's classroom, the distance learning students could also benefit from any student/instructor interactions occurring in the instructor's studio/classroom.

Additional research comparing the effectiveness of different EVC systems should incorporate a longer experimental instructional phase (50 minutes or longer) with ambiguity built into the instruction to enhance the potential for interaction. The short duration of the

instruction coupled with the lack of ambiguity in the presentation may have precluded student/instructor interaction and possibly hampered cognition. Students had insufficient time to acclimate to the environment. The instructor had prepared a short presentation with basic overhead visuals that essentially made the presentation too effective for facilitating interaction. Subjects had no need to ask a question.

Researchers should strive to find an instructor with prior videoteleconferencing teaching experience to conduct this type of study. As in this experiment, the instructor should also be the subjects' normal professor. Subject familiarity with the instructor and prior instructor EVC experience could help alleviate concerns about artificiality, increase the potential for interaction, and possibly reduce the distractions of the technology.

For further research. The heuristic nature of this study makes it an ideal model for conducting further research into the effectiveness of interactive EVC systems. Longitudinal research, using this study as a model, could reveal possible differences in effectiveness as measured by four factors: cognition, interaction, and student as well as instructor satisfaction. A longitudinal study may be the only way to effectively evaluate the impact of student/instructor interactivity as it has been reported that college students first experiencing interactive television instruction felt less involved in the class and did not ask questions of the instructor even when two-way audio was available (Ritchie & Newby, 1989). Long-term research could also circumvent some of the limiting factors that inhibited interaction in this study: artificiality, the short duration of the instruction, and the impact of the medium on an inexperienced EVC instructor's teaching style.

As described in the literature, contradictory results and conflicting research exist regarding the effect of student/instructor interaction on cognition. Sounder (1993) reported that older, more motivated students need less interaction, but most educators contend that interaction adds to the educational process (Moore et al., 1990). Although one-way EVC has

been shown to be effective, further comparative research on the impact of interaction in different types of EVC systems could prove fruitful. The effects of student/instructor interaction on cognition could be more effectively measured over time as both the students and instructor become more familiar with the setting and possibly less inhibited.

Identifying instructor attitudes and preferences about different types of EVC systems could be beneficial. Further research is needed to determine which EVC system instructors prefer and the importance of visual feedback derived from the instructor's ability to see the students. Instructor satisfaction with the delivery medium could enhance student cognitive performance and student/instructor interactivity.

Moore et al. (1990) recommended further research on developing teaching techniques that exploit the attributes of the medium. It has been reported that straight lecture underutilizes the attributes of videoteleconferencing (Kruh & Murphy, 1990). Learning becomes a passive experience for the student. Although the instructor in this researcher's experiment attempted to engage the students in the learning process several times, the presentation never got beyond the straight lecture phase. Further longitudinal research could discover effective techniques that maximize the attributes of interactive videoteleconferencing systems.

Although there was no significant difference between male and female cognition in this research, a larger sample could reveal significant differences in cognition. Further research is needed to determine if their is any difference between male and female student cognition in EVC on a variety of subjects.

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Appendix A

Test and Questionnaire Instrument for Groups A and B

Please answer the following three pages of questions regarding the material presented along with several demographic and attitudinal questions related to this research. Your responses will be kept confidential and you will remain anonymous.

1. The frequency spectrum dedicated for the use of MMDS technology is _________ Mhz to _________ Mhz.

2. Of the two services, MMDS and ITFS, which service is used for non-commercial education? ___________

3. Commercial MMDS operators now lease these dedicated frequencies for expanded programming distribution. These dedicated frequencies/channels are known as _________.

4. For over-the-air entertainment transmissions, private companies would use __________ frequencies/channels as a vehicle to deliver their product from a transmission site to the consumer's home.

5. ________________ serves as the main distribution point for telecast of educational programming from ASU to the Phoenix metro area.

6. In a one-way videoteleconferencing system, students communicate or interact with the instructor via ____________.

7. Videoteleconferencing technology is one of many tools used to reach geographically distant or separated students. What type of learning is this? ______________

8. With two-way video and two-way audio videoconferencing, the instructor can see and hear the remote students. (True or False) ___________

9. Which is NOT one of the three main components of an ITFS classroom at ASU? (Circle the correct letter)

   a. Microphone
   b. Radio receiver
   c. Video camera
   d. Television monitor

10. At the present time, ITFS channels/frequencies are underutilized.

    (True or False) _________

11. What is your age? _______

(over)

12. What is your gender?

    a. Male
    b. Female

13. Please indicate your current class standing at the university:

    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior

14. What is your race?

    a. African American
    b. American Indian
    c. Hispanic
    d. Oriental
    e. White Caucasian
    f. Other

15. What is your current grade point average at Arizona State University? (Remember, this questionnaire is totally anonymous. There is no way to relate it to you. Scores will be group-analyzed.)

    ______ GPA

16. Have you had any academic or professional experience with videoteleconferencing?

    a. This is my first time in a videoteleconferencing environment
    b. I have participated in at least one videoteleconferencing class or conference but do not consider myself an expert on videoteleconferencing technology
    c. I have extensive experience working with videoteleconferencing technology

The remaining questions concern your perceptions and attitudes about the technology used to deliver the instruction. Please place an "X" in the underlined blank that best represents your perception or attitude.

17. The educational videoteleconferencing you participated in is:

good	___ : ___ : ___ : ___ : ___	bad
effective	___ : ___ : ___ : ___ : ___	in-effective
difficult	___ : ___ : ___ : ___ : ___	easy
worthless	___ : ___ : ___ : ___ : ___	valuable
interesting	___ : ___ : ___ : ___ : ___	not interesting
negative	___ : ___ : ___ : ___ : ___	positive

(over)

18. Is student/teacher interactivity--the ability for students and instructors to spontaneously communicate during class--important in a videoteleconferencing course?

____ very important	____ important	____ neutral	____ unimportant	____ very unimportant

19. If given a choice between taking a videoteleconferencing course and taking the same course in a traditional classroom setting, which delivery method would you choose?

___traditional classroom ___videoteleconferencing ___ doesn't matter

20. When compared to videoteleconferenced courses, traditional face-to-face classroom education is:

bad	___ : ___ : ___ : ___ : ___	good
effective	___ : ___ : ___ : ___ : ___	in-effective
easy	___ : ___ : ___ : ___ : ___	difficult
worthless	___ : ___ : ___ : ___ : ___	valuable
not interesting	___ : ___ : ___ : ___ : ___	interesting
negative	___ : ___ : ___ : ___ : ___	positive

21. As a student, were you satisfied with your ability to interact (communicate) with the instructor during the lecture/presentation? _________ Why?

22. Did the distance learning classroom technology inhibit you from communicating with the instructor during the lecture/presentation? __________ Please explain your answer below.

Appendix B

Post-experiment Interview Notes with Instructor

Researcher Question-

Which educational videoteleconferencing system did you prefer?

Instructor Answer-

I preferred the two-way.

Researcher Question-

Why?

Instructor Answer-

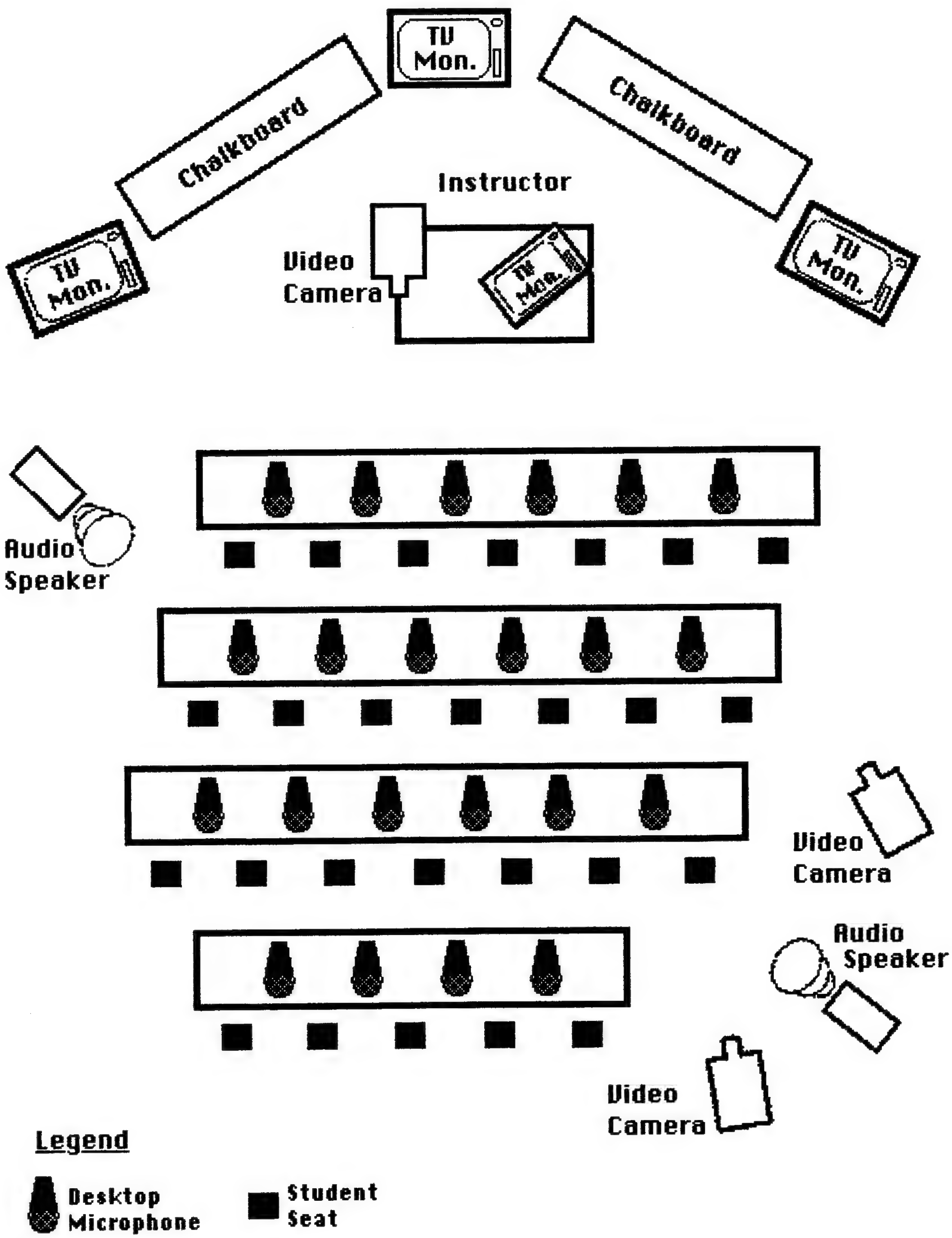
I could see the students. It gave me the ability to see if the students understood the lecture. The ability to see the students humanized the process. Students became non-existent with one-way video. The human factor was lost. The students don't exist with one-way video because I can't see them. I'd like to have students in the room with me when I teach a videoteleconference course. That way I could play to the students and forget the cameras.

Appendix C

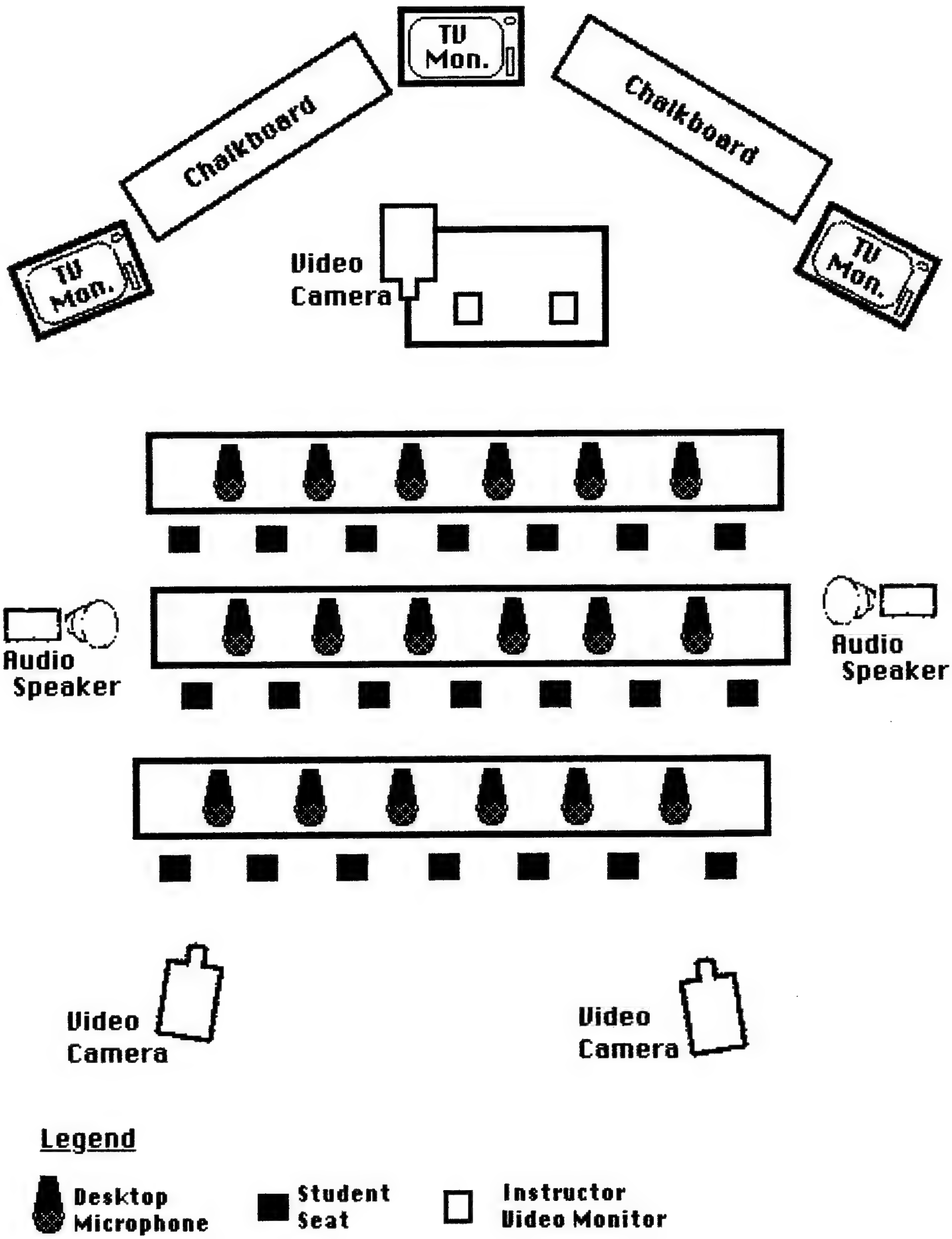
Studio/classroom Configurations

The attached pages show how the instructor's and the students' studio/classrooms were configured for this study.

Instructor's Studio/classroom Configuration (BAC 328)



Students' Studio/classroom Configuration (BAC 318)



Appendix D

Human Subjects Institutional Review Board Approval

The Human Subjects Institutional Research Board at Arizona State University approved the application to conduct this research project (viz., "A Comparison of One-way Video and Two-way Video Educational Videoteleconferencing") on February 16, 1995. A copy of the board's approval memorandum is attached on the next page.

Institutional Review Board (IRB)
Vice President for Research and Strategic Initiatives
Arizona State University
Box 878206
Tempe, AZ 85287-8206
602/965-6788 FAX: 602/965-9684

M E M O R A N D U M

February 16, 1995

TO: Mary Lou Galician
Journalism & Telecommunication

FROM: Carol Jablonski CJ
Human Research Coordinator

SUBJECT: "A Comparison of One-Way Video and Two-Way Video Educational Videoteleconferencing Delivery Systems"
HS #03278-95

The Human Subjects Institutional Review Board has approved your above-referenced application for the conduct of research involving human subjects on February 15, 1995.

The IRB would like to remind you that Federal regulations require investigators to immediately report to the Board any complaints, incidents, or injuries that may occur as part of the project.

Project directors are responsible for maintaining auditable files. Please sign below indicating your willingness to comply with these procedures, and return one copy with original signature to me at the Office of Human Research Administration (mail code 8206) for our files.

kh

xc: Craig Hendrix

Mary Lou Galician
Name

2/21/95
Date

Appendix E

Sample Consent Letter for Adults

Dear Student,

I am a graduate student under the direction of Professor Mary-Lou Galician, in the Walter Cronkite School of Journalism and Telecommunication at Arizona State University and I am conducting research to evaluate the effectiveness of educational videoteleconferencing systems. As volunteer participants, you will receive a brief lecture via a videoteleconferencing system in which you may be recorded on videotape. All videotapes will be erased after the project has been completed to ensure confidentiality. After the lecture, you will complete a short test and questionnaire about videoteleconferencing. This research will take approximately 35 minutes.

Your participation in this study is voluntary. If you choose to participate, it will not affect your grade or reflect negatively on you. The results of the research may be published, but your name will not be used.

If you have any questions concerning the research study, please call me at (602) 940-3805 or Dr. Galician at (602) 965-5066.

Sincerely,

Craig L. Hendrix
ASU Graduate Student

* * * * * * * * * *

I give consent to participate in the above study and I also give permission to be videotaped as outlined above. The questionnaire is anonymous, thereby ensuring confidentiality of responses.

______________________   ________________
Signature   Date

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review board, through Carol Jablonski, at (602) 965-6788.

Appendix F

Recruitment Letter

Craig Hendrix, a graduate student under the direction of Professor Mary-Lou Galician, in the Walter Cronkite School of Journalism and Telecommunication at Arizona State University is conducting a research on Educational Videoteleconferencing Delivery Systems on 23 February, 1995, during our normal class time for TCM-435 (4:40 to 5:55pm). Please report to the Business C Wing room 313 no later than 4:40pm.

He is recruiting subjects to participate as students in a distance learning environment in which the volunteer students receive a brief lecture and are subsequently given a short test and questionnaire. It will take approximately 35 minutes.

Your participation in this study is voluntary. If you choose to participate, it will not affect your grade or reflect negatively on you. The results of the research may be published, but your name will not be used.

If you have any questions concerning the research study, please call Craig Hendrix at 940-3805 or Dr. Galician at 965-5066.

Appendix G

Oral Group Instructions Transcript

I'm a graduate student in the Walter Cronkite School of Journalism and Telecommunication at Arizona State University and I'm conducting research about educational videoteleconferencing for my Applied Project under the direction of Dr. Mary-Lou Galician.

Your participation in this study is voluntary. Although the content of the lecture this afternoon is directly related to emerging telecommunication technologies, if you choose not to participate, it will not affect your grade. The results of the research may be published, but your name will not be used. All information you provide will be strictly confidential. No one other than the researchers will see your individual scores and opinions, and these will be anonymous anyway. You can quit anytime you like without prejudice. If you have any questions about this research, please call Craig Hendrix at 940-3805.

You will be presented a live 10 to 15-minute segment of instruction about this technology on which you will be tested. Even though your score on the test will not count toward your grade, please treat this class like it were any other, as if your test actually counted. Feel free to ask the instructor questions at any time during the lecture. After the presentation, we will move back to room 313 where you will complete a short test and questionnaire on the material presented. Your test results and demographic data will be compiled along with your opinions about the way the instruction was delivered. Remember to treat this experiment like it were just another class. Thank you and good luck!

Appendix H

Sequence of Events

1640 - 1645: In room 313, randomly divide subjects into two groups with equal numbers of male and female participants. Have students sign consent forms. Give participation brief. Move Group A to BAC 318 for experiment. Group B will remain until Dr. Galician comes for them (Craig Hendrix, Sid Vician, Melissa Miller).

1645 - 1705: Introduce and conduct experiment for Group A (Two-way Video) (Craig Hendrix, Tom Crosby, Sid Vician)

1705 - 1715: Move Group A to BAC 313 for posttest and questionnaire. Move Group B move to BAC 318 when Dr. Galician comes for them (Melissa Miller)

1710 - 1730: Introduce and conduct experiment for Group B (One-way Video) (Craig Hendrix, Tom Crosby, Sid Vician)

1730 - 1740: Move Group B to BAC 313 for posttest and questionnaire. Move Group A to BAC 318 to wait for debrief. Group B will join Group A in BAC 318 when finished with the posttest (Melissa Miller, Craig Hendrix)

1747 - 1755: Debrief students in BAC 318 (Craig Hendrix)

Appendix I

Student/Instructor Interaction Observation Form

Place a check in the appropriate column for each type of verbal communication by students with the instructor. If possible, indicate in seconds the approximate length of the communication next to each check. There are two categories with two sub-categories each. One major category includes questions initiated by a student while the other consists of student responses to the instructor.

Student Questions are either **Restricted** thinking questions classified as memory or knowledge or **Expanded** thinking questions classified as interpretation, analysis, or synthesis. Student Responses to instructor queries should be classified as either **Restricted** thinking responses as in the questions category or **Expanded** reactions which extend the level of participation and thinking.

Student Questions		**Student Responses**	
Restricted	**Expanded**	**Restricted**	**Expanded**